MIT Lincoln Labs - Defense Holiday Patents (January 2026), contact: Asha Rajagopal, Asha.Rajagopal@ll.mit.edu

Patent title, as issued	Patent Number	Date issued	Inventor name(s)	Brief Description of Patent (Claims/Field of Use)	Technology area subfields	Facilities available that may support continued R&D
Metalized double-clad optical fiber	10,073,218	9/11/18	Zachary J. Setmire, John J. Zayhowski, Jonathan Wilson	The innovation is a novel form of optical fiber, enhanced through metallization of the polymer cladding. The basic structure includes a double-clad fiber with polymer coatings, mainly for use in fiber lasers and amplifiers to guide and amplify light as optical power increases. Integral to this new fiber is a thin layer of vacuum-deposited chrome upon the polymer cladding, further electroplated with a thicker copper layer. The purpose of this design is to overcome a key issue facing conventional optical fibers: heat dissipation. As the optical power surges, the fibers must shed more heat, typically hard to achieve with a polymer cladding, especially at high altitudes. The metallization and specialized structure allows the fiber to cool down by channeling heat via a heatsink from within the fiber's core and cladding layers. This design enables efficient guiding and amplifying of high-power optical signals, even in high-altitude conditions.	Protective Coatings	
High power light absorbers having anti-reflection coating	12,066,679	8/20/24	Steven J. Augst, Peter O'Brien, Jonathan Wilson	High-power light absorbers (HPLAs) are cutting-edge technology for advanced light handling and management. These absorbers can diminish the effects of back-scattered light, mitigate stray light, and withstand high optical power densities. HPLAs include a substrate constructed from thermally conductive material and are coated with an anti-reflection (AR) layer. A thin layer of powerfully absorbing material is situated between the AR and substrate coating. Moreover, HPLAs can be utilized with or without baffling as beam dumps in high-power lasers. What sets HPLAs apart from other light-absorbing technologies is its unique configuration and its capacity to handle high optical powers. It offers an extraordinary AR coating and a thick layer of absorbing material precisely positioned and designed to manage stray light effectively. Another distinctive attribute of HPLAs is their efficient cooling mechanism; they are cooled using a fluid like water or air, allowing them to handle extreme optical power without suffering degradation or failure.	Protective Coatings	
Stackable Battery Cells With Individual Cell Management	18/183,548	pending	Theodore Bloomstein	This invention features an array of high-capacity batteries, each constructed from a series of stacked cells with variable properties for optimized performance. The cells include integral anode and cathode layers, an ion conducting membrane, and distinct top and bottom layers that house complex circuitry for battery monitoring and control. This technology integrates individual battery control circuits to facilitate direct electrical interfacing, enabling precise manipulation of battery cell operations. The distinctiveness of this battery array lies in its advanced control system, which permits fine-tuning of battery function to meet specific energy needs. An overarching battery array control circuit interfaces with each individual battery's control circuit, crafting a network that offers unparalleled command over the entire array's performance. This system fosters enhanced efficiency, reliability, and safety, making it a standout in the realm of energy storage solutions.	Miscellaneous	
Combined intensity and coherent change detection in images	10,037,477	7/31/18	Miriam Cha, Rhonda D. Phillips, Patrick J. Wolfe, Christ D. Richmond	This technology is a dual-phase change detector that identifies variations in scenes by analyzing pairings of images over time. The system first employs a noncoherent intensity change detector to spot large-scale disparities between the first and second images, producing a value for these differences for the corresponding pixels in both images. In the event that these changes surpass a certain threshold, the system switches to a coherent change detector designed to discern small-scale alterations. This technology is unique in its dichotomy approach to detecting changes, allocating for both grand-scale and minor alterations, yielding a holistic view of the scene over time. This view is achieved via the composite change value generated by combining the large- and small-scale change values, catering to its comprehensive analytical capability. The scalable thresholds utilized for determining changes ensure versatility and adaptability to diverse scenarios.	Sensors- Imaging & Optical Sensing	Microelectronics Laboratory
Temporal structured-illumination motion-detection system	9,289,120	3/22/16	Nandin Rajan, Andrew M. Siegel	This invention offers an innovative solution for the detection and tracking of fast-moving objects, including rapid eye movements termed "saccades." It operates by generating two or more images of the object in a single frame from a video camera or similar detector. This process is accomplished by illuminating the moving object using sequentially activated, or "strobed," light-emitting diodes (LEDs). Notably, these light sources activate at a rate surpassing the frame rate of the detector, yielding multiple images within one frame. What sets this technology apart is its ability to achieve significantly higher temporal resolution than standard video equipment operating between 15 to 30 frames per second (fps). It uses readily available, cost-effective components, thereby bypassing the need for expensive high-frame-rate video hardware. Particularly important is the invention's application in saccadometry, which involves the tracking and analysis of rapid eye movements.	Sensors- Imaging & Optical Sensing	Microelectronics Laboratory
Systems, methods, and apparatus for sensitive thermal imaging	9,835,885	12/5/17	Robert K. Reich, Harry R. Clark, Carl O. Bozler, Shaun R. Berry, Jeremy B. Muldavin	The technology detailed revolves around a high-pixel-count, uncooled thermal imaging array system that makes use of liquid crystal (LC) microcavity transducers separate from the read-out integrated circuit (ROIC). These transducers convert incoming infrared (IR) radiation into changes in birefringence, which can then be quantified using visible light. In essence, the system leverages the temperature sensitivity of the LC birefringence to convert the IR scene into a visible image. What sets this technology apart is its robust noise performance, indicated by measurements from sample arrays reflecting a similar quality to bulk samples. The high-fill-factor arrays constructed on fused-silica substrates can be fine-tuned to achieve drastically improved temperature sensitivity. For further optimization, an additional IR absorber layer might be integrated into the manufacturing process to adjust the structure according to the infrared.	Sensors- Imaging & Optical Sensing	Microelectronics Laboratory
Methods and apparatus for deployable sparse-aperture telescopes	11,048,062	6/29/21	Bryan M. Reid, Mark Silver, Robert Martinez, Alan DeCew, Adam Shabshelowitz, Michael Chrisp	This imaging system uses a novel design that includes a metering structure surrounded by a plurality of foldable members. Each of these foldable members has an arm made of a strain deployable composite and houses a reflector. The arm is specifically engineered to control the proximity of the foldable member, both toward and away from the metering structure, thus allowing flexibility in operation. What sets this imaging system apart is its ability to form a sparse aperture when in second state. Thanks to the reflector within each foldable member, the aperture augments the potential of the system to capture refined imagery. This innovation opens the way for enhanced resolution and imaging capabilities, which outpace conventional imaging systems. The strain deployable composite further allows for easy and efficient manipulation of the imaging system, making the technology more practical and adaptable.	Sensors- Imaging & Optical Sensing	Microelectronics Laboratory
Devices and methods for optically multiplexed imaging	10,070,055	9/4/18	Ralph Hamilton Shepard, Yaron Rachlin	The time-multiplexed waveform generator is an innovative technology that includes several vital components, such as a wavelength splitter, intensity modulators, adjustable delay lines, and a wavelength combiner. The wavelength splitter receives an optical signal and splits it into multiple frequency components. These frequency components are then received by multiple intensity modulators, which pass each frequency for a selective time period before extinguishing it for the rest of the chirp time, producing a number of first output signals. This technology stands out for its ability to control phase of each frequency component, compensating any relative drifts of path lengths, and phase coherently stitching a number of sub-chirps together, thanks to the adjustable delay lines. This unique approach allows the creation of a stair-step waveform output signal when the second output signals are combined by a wavelength combiner.	Sensors- Imaging & Optical Sensing	Microelectronics Laboratory
Pressure tolerant camera	18/405,303	pending	Gregory Cappiello, George Turner, Brian Edwards, Emma Landsiedel, Ryan Little	The pressure-tolerant camera system is designed for extreme environments such as deep-sea, terrestrial, airborne, and space. It features an enclosure filled with an incompressible fluid and a viewport that allows light to pass through. Inside the enclosure, a digital image sensor captures images, while a series of mirror lenses reflect incoming light from the viewport onto the sensor. The mirror lenses are crafted with sophisticated freeform optical surfaces, enhancing the system's wide field of view and fast aperture capabilities. Additionally, the system integrates advanced artificial intelligence for object recognition and autonomous decision-making, enabling selective data storage and transmission. For deep-sea deployments, it includes components like depth sensors, compasses, hydrophones, and illumination modules, making it adaptable for use as an autonomous lander or within unmanned underwater vehicles.	Sensors- Imaging & Optical Sensing	Microelectronics Laboratory
Methods and systems for time-encoded multiplexed imaging	10,425,598	9/24/19	Joseph Hsuhuan Lin, Michael Kelly, Ralph Hamilton SHEPARD, III, Brian Tyrrell	The technology involves an imaging system using a dynamic, variable coded mask, like a spatial light modulator (SLM), to concurrently time-encode several degrees of freedom of a light field. The system uses a detector and processor to decode the encoded information at the pixel level, either on an integrated circuit connected to the detector or on a circuit external to the detector. For instance, the SLM, detector, and processor may develop modulation sequences representing a system of linear equations; the variables represent a degree of freedom of the light field being sensed. This technology stands out because if the number of equations and variables create a fully determined or overdetermined system of linear equations, a solution can be found through a matrix inverse. Otherwise, a solution can be generated using compressed sensing reconstruction techniques, given the signal is sparse in the frequency domain. The dynamic nature and flexibility of the system offer improved image processing capabilities.	Sensors- Imaging & Optical Sensing	Microelectronics Laboratory
Method of and system for optimizing NURBS surfaces for an imaging system	10,437,943	10/8/19	Michael Chrisp	This invention offers a process for augmenting NURBS optical surfaces in imaging systems. Using the principles of ray tracing, the method involves determining the number and location of field point sources and automatically increasing these until the image spot size variance is below a preset threshold. Likewise, the number of rays for each field point source is also iteratively increased until a set number of rays intersect each NURBS rectangular grid sub-area. What sets this technology apart is its automated approach to enhancing imaging resolution by the utilization of ray tracing techniques. Adjustments are made to the grid control points of each NURBS surface while maintaining symmetry or inviting freeform shapes, with the iterations driven by an optimization algorithm based on ray tracing. Iterations continue until image spot sizes meet set requirement or until improvement in spot size is below a predetermined value, implying a continuous strive towards achieving an optimal imaging system.	Sensors- Imaging & Optical Sensing	Microelectronics Laboratory
Wide field of view narrowband imaging filter technology	10,794,819	10/6/20	Jonathan Ashcom, Sumanth Kaushik	A method and apparatus used for detecting gaseous chemicals. The method and apparatus use an interferometer to filter received light by wavelength, creating an image only using light with wavelengths that are affected by the presence of a gaseous chemical. A reference image composed of light with wavelengths unaffected by the presence of a gaseous chemical is also created and used as a reference. A gaseous chemical is detected where the ratio of the intensity of the two images changes. Despite the high spectral resolution of the filter, the system can operate with a very wide field of view.	Sensors- Imaging & Optical Sensing	Microelectronics Laboratory
Phosphor-loaded waveguide	11,275,868	3/15/22	Michael W. Geis, Joshua Kramer, Karen M. G. V. Gettings, Marc J. Burke, Mankuan M. Vai, Theodore M. Lyszczarz	The presented waveguide is an innovative optical solution tailored to boost light introduction. It employs a luminescent material that can be placed within or around its perimeter. This waveguide can comprise several planar layers, each having diverse refractive indexes, and the luminescent material can be arranged along the edge of these layers. Once the light within the waveguide encounters the luminescent material, it emits light thereby supplementing the waveguide's light. This waveguide holds distinct advantages. The integration of luminescent material not only enhances the amount of light introduced into the waveguide, but it also adds more light sources inside. This additional light introduces a unique challenge to probe introduction, making it a task to probe the waveguide without obstructing some portion of the destined light. The luminescent material chosen can be a phosphor.	Sensors- Imaging & Optical Sensing	Microelectronics Laboratory
Method and apparatus for motion coded imaging	9,681,051	6/13/17	Yaron Rachlin, Sumanth Kaushik	The present invention is an imaging apparatus and process that facilitates high-resolution, extensive field-of-view, and high-sensitivity imaging. This camera system works on the principle of movement of an optical element, such as a spatial filtering mask or even the camera, to apply different spatial filtering functions to a scene needing imaging. The features of the spatial filtering mask implementing the filtering functions are adjacent along an axis of the mask, and the pitch of these features is smaller than the pitch of the sensor elements. This technology is differentiated by its use of an imaging reconstructor aware of the filtering functions. This reconstructor can generate a high-resolution image from the corresponding low-resolution coded imaging data captured by the imaging system. This approach offers notable benefits over conventional high-resolution, wide-field imaging, including the ability to utilize large-pitch, more cost-effective sensor arrays and consequently to transfer and store substantially less data.	Sensors- Imaging & Optical Sensing	Microelectronics Laboratory
Optical filters with engineered birefringence	9,841,606	12/12/17	Mordechai Rothschild, Kenneth Diest, Vladimir Liberman	The invention is an advanced optical filter that uses carefully engineered nanomaterials or "metamaterials." This filter is remarkable for its ability to offer narrow spectral bandwidths while also offering high levels of rejection for out-of-band radiation. Additionally, it can maintain a wide acceptance angle. These properties are largely due to the unique features of the metamaterials, which have been designed with a specific birefringence determined by their internal geometry and material composition. One significant aspect of the technology that sets it apart is its zero-crossing capability. This means the filter can achieve an acceptance angle that is effectively decoupled from the bandwidth, creating an adaptable filter that can operate efficiently across a vast range of wavelengths. The innovative engineering of materials endows the filter with this groundbreaking attribute.	Sensors- Imaging & Optical Sensing	Microelectronics Laboratory
Rare earth spatial/spectral microparticle barcodes for labeling of objects and tissues	10,533,133	1/14/20	Paul Bisso, Albert Swiston, Jisook Lee, Patrick S. Doyle	The developed technology is centered around polymer microparticles spatially and spectrally encoded using upconversion nanocrystals (UCN). These UCNs, possessing spectrally distinguishable emission spectra, are strategically positioned in different portions of the encoding region within each microparticle. This design allows for the precise labeling and identification of various articles and tissues. The uniqueness of this technology lies in its ability to use UCNs for encoding microparticles, making it possible to create labels with distinct spectral patterns. This spectral differentiation offers a higher level of detail and specificity, resulting in superior object and tissue labeling accuracy compared to other methods.	Sensors- Imaging & Optical Sensing	Microelectronics Laboratory

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Space-time modulated active 3D imager	9,514,378	12/6/16	Nicholas Lloyd Armstrong-CrewsBryce Jason REMESCH	This technology is a three-dimensional imager that functions differently from conventional imagers. This imager operates by illuminating a scene with modulated light, which consists of a viewpoint-independent pattern. This light is followed up by detecting diffuse reflections from the scene to create an initial image. That image is then digitally enhanced by correcting the background and comparing it against a known reference image, finally resulting in a depth image. What sets this imager apart is that it is not limited by size, weight, and power considerations like its predecessors. It can also effectively image in sunlit environments, an ability absent in previous technology. Furthermore, there is a significant improvement in signal-to-noise performance. These improvements address the traditional drawbacks of readout circuitry bottlenecks and SWaP constraints prevalent in existing 3D imagers.	Sensors- Imaging & Optical Sensing	Microelectronics Laboratory
Method and kit for stand-off detection of explosives	8,935,960	1/20/15	Charles M. Wynn, Robert W. Haupt, Sumanth Kaushik, Stephen T. Palmacci	The kit for detecting explosives includes a pulsed focused energy source located away from a targeted surface or substrate. This energy source has a magnitude potent enough to release the internal energy of any explosive substance if present on the substrate. The release of this internal energy consequently generates an acoustic wave. Furthermore, the kit includes a detector designed to identify these acoustic waves at a certain detection distance away from the substrate. One factor that differentiates this technology is its reliance on the generation and detection of acoustic waves for the identification of explosives. The method of employing a pulsed focused energy source is innovative, and its success in triggering an explosion does not rely on the physical interaction between the energy source and the explosive material. Instead, this technology uses the correlation between the energy released from explosives and the subsequent acoustic wave to identify the presence of explosives.	Sensors- Chemical, Biological, & Explosive Detection	Trace Vapor Detection Testbed
Retroreflectors for remote detection	9,316,593	4/19/16	Michael Switkes, Mordechai Rothschild	This optical detection system comprises a retroreflector and a layer of material that alters its transmission under exposure to a certain phenomenon. The retroreflector, possibly an array of or individual prisms or cat's eye microspheres, gets illuminated by a radiation source with multiple optical properties. As it happens, a sensor is employed to sense radiation that is retroreflected back through the layer. The layer could also include elements such as a colorimetric dye. What distinguishes this technology is its versatility and detection potential. The retroreflector and layer could be situated on a moving carrier like a projectile or vehicle so that the system can function within a variety of mediums. This versatility makes it possible to detect changes in optical properties over larger areas. Moreover, in detecting a phenomenon, retroreflective elements can be utilized across a region of ground or distributed within the atmosphere.	Sensors- Chemical, Biological, & Explosive Detection	Trace Vapor Detection Testbed
System and technique for mitigation of clutter in radar	10,955,524	3/23/21	Molly K. Crane, David C. Mooradd	This invention pertains to both a system and technique designed specifically for minimizing the detrimental effects of clutter in a radar environment. The unique approach utilizes linear co-polarized measurements, which can be easily integrated into standard radar signal processing procedures. This method does not compromise the speed or efficiency of the system. The distinguishing factor for this technology is its remarkable ability to address the common problem of clutter without hampering radar performance. Ensuring that regular workings of the radar are not slowed down, the technique offers an edge over other clutter-reducing techniques in the market.	Sensors- Radar & Lidar Systems	Microelectronics Laboratory
Phase doppler radar	11,391,832	7/19/22	David Burke	The phase Doppler radar system consists of a pulse Doppler receiver/transmitter subsystem and a processing subsystem. The system collects pulses and determines their initial undifferentiated phase, differentiates the pulses, and calculates the differentiated phase. It then carries out a linear fit on the differentiated pulses, producing a slope and intercept as a result. From this process, initial estimates of coefficients for a nonlinear fit equation are determined. The system tests these initial coefficients against a nonlinear least-squares fit and produces a nonlinear fit result. The technology differentiates itself through the use of phase information in radar signal processing, improving the system accuracy and reliability. Thereafter, the system calculates a goodness-of-fit (GoF) statistic linked with the nonlinear fit result and declares a detection event if the GoF is superior to a GoF tied to Gaussian noise. This method renders the system more immune to noise, boosting its capacity to detect targets accurately.	Sensors- Radar & Lidar Systems	Microelectronics Laboratory
Data-driven angular jitter estimator for lidar	11,830,194	11/28/23	Ethan Phelps, Charles Primmerman, Eric Statz	This specialized lidar imaging system is designed for use in satellite technology. It leverages recent advances in compact fiber lasers and single-photon-sensitive Geiger-mode detector arrays, enabling feasible space-based ground imaging. A unique feature of this system is its ability to compensate for the problem of angular jitter, which often disturbs the accuracy and clarity of space-based 3D lidar data because of the long distances involved. The system uses an innovative method of estimating the 2-axis jitter time series directly from the lidar data, in tandem with the estimation of a single-surface model of the ground to offset it. What sets this technology apart is its unique approach to mitigating the impact of angular jitter without resorting to costly and cumbersome solutions like mechanical isolation, advanced IMUs, star trackers, or auxiliary passive optical sensors. By applying an Expectation Maximization process, the system enhances the signal and background detections while maximizing the joint posterior probability density of the jitter and surface states. This processing strategy results in reduced blurring equal to the optical diffraction limit.	Sensors- Radar & Lidar Systems	Microelectronics Laboratory
Passive wide-area three-dimensional imaging	11,580,694	2/23/23	Robert Sweeney	The technology enhances 3D image formation from full-motion videos using a cost- and energy-effective method. Instead of relying on large, power-burning, active 3D imaging sensors, this technology involves registering and mapping video frames to the scene coordinates by leveraging the data from the platform's trajectory with respect to the scene. This method uses a mathematical relationship that involves the height map of the scene, projected angular velocity of the platform, and spatial gradient of the registered frames. Creatively circumventing the limitations posed by both active and passive 3D imaging techniques, this technology distinguishes itself through the use of full-motion video acquired from a moving platform. The primary differentiator lies in the real-time processing ability to produce height maps of the scene from a full-motion video and trajectory, proving both efficient and robust.	Sensors- Radar & Lidar Systems	Microelectronics Laboratory
Methods and apparatus for phased array imaging	10,571,569	2/25/20	Juan C. Montoya, Antonio Sanchez-Rubio, Harold C. Payson, Robert E. Hatch ,Richard Heinrichs, Dale G. Fried	This innovative technology is a process for imaging scenes by using continuous wave (CW) light beams. It creates a temporally varying optical intensity pattern that illuminates parts of the scene. When a photon scatters or reflects off these parts, it is detected with a single-photon detector. The unique crux of the technology is estimating the distance between the photon detector and the scene's portion on the basis of the optical intensity pattern and the photon's time of flight. This technology stands out because it utilizes the unique properties of light, combining CW light beams with unique optical intensity patterns. It offers a novel way of estimating distances by creating a bridge between the photon detector and the object. The blend of these aspects endows the technology with great potential in multiple domains that require a precise understanding of the surroundings.	Sensors- Radar & Lidar Systems	Microelectronics Laboratory
Lidar resistant to interference and hacking	10,852,433	12/1/20	Jerry C. Chen	This lidar system using light to determine the distance to an object can be leveraged for autonomous vehicle navigation and detailed terrain mapping. Beyond range, it can also detect target speed, optical reflectivity, and spectroscopic signature. This lidar system employs modulation or encoding in each transmitted pulse to make the system more resistant to jamming and hacking, especially in environments where multiple lidars are operating. What sets this technology apart is the integrated processor that discriminates true return signals from false ones on the basis of the modulation of the transmitted pulses. During a time-of-flight (TOF) lidar operation, the presence of this modulation marks the return signal as genuine, while its absence indicates a false return. This distinguishing feature significantly enhances the lidar's resistance to interference, improving its reliability and security.	Sensors- Radar & Lidar Systems	Microelectronics Laboratory
Ferrimagnetic oscillator magnetometer	11,774,520	10/3/23	John F. Barry, Reed Anderson Irion, Jessica Kedziora, Matthew Steinecker, Daniel K. Freeman, Danielle A. Braje	Ferrimagnetic oscillator magnetometers are an advanced technology that doesn't involve the use of lasers to stimulate fluorescence emission from defect centers in solid-state hosts. Instead, these devices exploit the natural properties of ferrimagnetic crystals. By applying a magnetic field, the device shifts the resonance of entangled electronic spins housed within the crystal. The spin ensemble has a resonance linewidth that ranges between approximately 370 kHz and 10 MHz. The shifting resonance produces microwave sidebands, the amplitude of which is proportional to the magnetic field strength and frequency proportional to the magnetic field oscillation frequency. These sidebands can be coherently averaged, digitized, and processed, enabling magnetic field measurements with outstanding sensitivity and potentially reaching the spin projection limit of 1 attotesla/$\sqrt{}$[square root over (Hz)]. This method encodes magnetic signals in frequency rather than amplitude to reduce the typically strict requirements on the digitizer, thereby offering a distinct advantage over existing technologies.	Sensors- Position, Inertial & Field Sensors	Microelectronics Laboratory
Apparatus and methods for photonic integrated resonant accelerometers	11,493,530	11/8/22	Suraj Deepak Bramhavar, Paul William Juodawlkis	The accelerometers utilize photonic integrated circuit technology and standard micro-electromechanical systems (MEMS) technology to achieve high sensitivity, long-term stability and low size, weight, power, and cost (SWaP-C). The innovativeness lies in the use of optical transduction to enhance the scale factor of traditional MEMS resonant accelerometers by accurately measuring the resonant frequencies of diminutive tethers attached to a large proof mass. Examples of these accelerometers deploy ring resonators and linear resonators to assess tether frequencies. What sets this technology apart is the excellent precision it brings to measure frequencies of tiny tethers, which could be around 1 µm, attached to a large proof mass, around 1 mm. This design results in improved scale factor for traditional MEMS resonant accelerometers. By this integration of photonic integrated circuit technology with MEMS technology and optical transduction, these accelerometers offer high sensitivity and unbeatable stability while maintaining low SWaP-C.	Sensors- Position, Inertial & Field Sensors	Microelectronics Laboratory
Integrated resonant accelerometer using optical strain sensor	10,571,483	2/25/20	Suraj Deepak Bramhavar, Paul William Juodawlkis	This technology is an accelerometer that incorporates a proof mass, a tether, and a ring resonator designed to respond to strain by changing its resonant frequency conditions. It is mechanically structured such that a sustained strain from the sensing tether results in a change in the ring resonator's resonance condition. The device also features a wavelength locking loop system for adaptively maintaining an optimal center frequency of light energy at the resonant frequency of the sensing element. Where this technology differentiates itself is in its incorporation of a scale factor calibrator to stabilize the scale factor associated with the accelerometer. The accelerometer also includes a detection processor configured to receive detection signals and generate acceleration signals from them. These signals correspond to the amount of change of the resonant condition relative to a reference resonance condition, allowing for accurate, reliable measurements of acceleration.	Sensors- Position, Inertial & Field Sensors	Microelectronics Laboratory
Method and instrumentation for determining a physical property of a particle	9,594,011	3/14/17	William D. Herzog	The invention is a technology that determines physical properties or classifies particles based on these properties by evaluating the scattered light profile from a single particle. It can analyze particles including those with chemical structures that vibrate as a function of their properties. Such properties could be absorptive properties or chemical composition. The process involves detecting a scattered light spectrum and identifying at least two anomalous dispersive regions from it. The physical properties of the particle can be determined by taking these regions into account. The technology is highly differentiated because of its ability to efficiently and accurately handle low-density particle applications. Its sensitivity is particularly beneficial for detecting biological and chemical agents because it can identify physical properties even in particles with lower density. The detection approach employing anomalous dispersive region identification from a scattered light spectrum provides specific and detailed data to facilitate precise determination.	Sensors- Position, Inertial & Field Sensors	Microelectronics Laboratory
Oscillator-based Solid-State Spin Sensor	12,032,044	7/9/24	Danielle A. Braje, Jennifer Schloss, Linh M. Pham, John F. Barry, Erik R. Eisenach, Michael F. O'Keeffe ,Jonah A. Majumder, Jessica Kedziora, Peter Moulton, Matthew Steinecker	This advanced sensor boasts high performance while maintaining low volume, weight, and power. The sensor harnesses a self-sustaining oscillator established on a dielectric resonator with paramagnetic defects. This resonator is coupled to a sustaining amplifier within a feedback loop. Variations in magnetic fields lead to shifts in the resonator's resonance frequency, altering the oscillator's frequency. The magnetic field's value is thus encoded in the output shift or modulation of the self-sustaining oscillator. What sets this technology apart is the avoidance of optics and input microwaves in its design, bringing about its low-weight, low-volume (less than 1mL), and low-power (less than 300mW) attributes without compromising on the sensor's high sensitivity, which is recorded at or below tens of pT/$\sqrt{}$Hz. This combination of features makes it a robust and yet efficient solution for a wide range of applications.	Sensors- Position, Inertial & Field Sensors	Microelectronics Laboratory
Ground-based system for geolocation of perpetrators of aircraft laser strikes	10,718,613	7/21/20	Julia A. Fang, Brian Saar, Tom Reynolds, James K. Kuchar, Richard Charles Westhoff, Erin Tomlinson	The ground-based system consists of at least two spaced-apart sensors, each containing a large aperture lens with a laser line or passband filter to deliver light to a cooled charge-coupled-device (CCD) camera. These sensors detect off-axis scattered light from the laser source and form imagery that is processed to locate the laser source. The processor generates a vector from the intersection of planes of interest from the two sensors; this vector is then propagated to the ground by using a terrain map to establish laser origin coordinates. This system offers a unique solution by incorporating an alerting system for rapid law-enforcement response and post-event algorithms for overlaying laser beam direction with aircraft coordinates to aid in prosecution activities. As a result, the disclosed system provides consistent protection for high-criticality airspace around airports, leading to a greater potential for perpetrator apprehension, prosecution, and strong deterrent effects.	Sensors- Surveillance, Tracking & Autonomy	Microelectronics Laboratory
Assisted surveillance of vehicles-of-interest	9,864,923	1/9/18	Michael T. Chan, Jason R. Thornton, Aaron Z. Yahr, Heather Zwahlen	The technology is a computer-implemented image processing method for operating on image data that represent numerous vehicle images. The method, underpinned by a predefined vehicle attribute data model, processes a part of the image data to ascertain a vehicle feature in at least one of the vehicles represented in the images. It then processes the image data portion to generate associated vehicle data that represent the perceived vehicle feature. This technology stands out because it is uniquely programmed to handle a broad range of vehicle types and an array of vehicle images. The process, guided by the predefined vehicle attribute, allows for the identification of distinct vehicle features and the creation of vehicle data that depict these features - thus providing a comprehensive and precise vehicle imaging processing solution.	Sensors- Surveillance, Tracking & Autonomy	Microelectronics Laboratory

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Systems and methods for detecting objects in underwater environments	10,809,376	10/20/20	Michael T. Chan, Daniel J. Scarafoni, Alexander C. Bockman	This technology is an advanced sonar surveillance system designed for automated detection and classification of objects of interest in submerged or underwater environments. It is capable of detecting a variety of objects in echograms without any instructions or feedback from a human operator. One distinctive feature of this technology is a partially self-trained data model that makes use of non-echogram image data. The uniqueness of this technology lies not only in the automation and partial self-learning capabilities, but in its ability to associate geolocation information with the objects detected. This feature provides critical positional data crucial for various underwater tasks. Additionally, the system's self-learning ability coupled with its independence from human participation differentiates it from traditional sonar systems, making it highly efficient and versatile.	Sensors- Surveillance, Tracking & Autonomy	Microelectronics Laboratory
Method and apparatus for locating a target using an autonomous unmanned aerial vehicle	9,696,430	7/4/17	Michael Jihong Park, Charles Coldwell	The drone system described herein is an advanced unmanned aerial vehicle (UAV) that integrates sensor data to autonomously and efficiently find a ground-based target. The system employs a unique two-stage approach. The first stage involves a randomized flight, such as Lévy flight, that allows the drone to search vast ground spaces. The second phase includes a geolocalization process like a simplex minimization process, effectively guiding the drone toward the desired target. Unlike other UAVs that typically rely on predefined flight patterns and simple sensor data, this system's standout feature is its utilization of statistical methods to optimize target search time. The combination of Lévy flights and simplex minimization methods enables the drone to cover a wide range and fine-tune its location accurately. This level of autonomy and efficiency makes it a hugely differentiated capability in UAV technology.	Sensors- Surveillance, Tracking & Autonomy	Microelectronics Laboratory
Systems and methods for dynamic planning and operation of autonomous systems using image observation and information theory	10,618,673	4/14/20	Michael T. Chan, Ronald Duarte	The technology described is an autonomous navigation system, employing vision-based guidance to oversee trajectory planning as well as the execution of motion, thereby eliminating the need for external operator interactions. This sophisticated setup extends its operation to autonomously trace an object, aiming to achieve diverse viewpoints of the targeted object, thereby enhancing object identification. A unique addition to the technology is its robust reacquisition method. What sets this technology apart is its capacity to instantaneously react to non-cooperative moving objects, offering a substantial advantage in situations characterized by compromised or absent communication with external operators. Through its strategic blend of autonomy and object tracking, it surpasses contemporary systems by significantly speeding up response times and operation under challenging scenarios.	Sensors- Surveillance, Tracking & Autonomy	Microelectronics Laboratory
High fidelity systems, apparatus, and methods for collecting noise exposure data	10,264,999	4/23/19	Joseph J. Lacirignola, Trina Rae Vian, Christopher J. Smalt, David F. Aubin, Jr., David C. Maurer, Mary Katherine Byrd, Christine M. Weston, Kerry A. Johnson, Shakti Davis, Olha Townsend, Paul T. Calamia, Edward H. Chen, Paula P. Collins	The technology is a complex system, apparatus, and method designed for collecting, interpreting, and utilizing noise exposure data. This system uses sensors to gather an analog signal expressing impulse noise sound pressure and another analog signal showing continuous noise sound pressure. To translate these analog signals into digital ones, at least one analog-to-digital converter (ADC) samples the signals at a frequency equal to or greater than double the inverse of the minimum impulse rise time. The system also includes accelerometers for data gathering near and far from the sensors. What makes the system stand out is its intricate processing mechanism. A primary combining node blends the digital signals to represent both the continuous noise and the impulse noise. It consists of a shock-artifact detection filter that identifies time frames that include a shock artifact based on the recorded accelerometry data. Apart from this, a frequency filter generates a background-removed audio signal, while an adaptive filter estimates the shock artifact. A secondary combining node then produces a shock-artifact-free audio signal, differentiating it from other noise data interpretation systems.	Sensors- Surveillance, Tracking & Autonomy	Microelectronics Laboratory
Method and system for distribution of an exposure control signal for focal plane arrays	7,501,634	3/10/09	Robert K. Reich, Bernard Kosicji, Dennis Rathman, Richard Osgood, Michael Rose, R. Allen Murphy, Robert Berger	The invention is a large-format imager comprising an array of pixels designed to convert electromagnetic radiation into electrical signals. Each pixel contains a photodiode that converts light intensity from high-frequency radiation into electrical charge, a reset switch for resetting the photodiode, circuitry for sampling the produced electrical charge, a photoswitch to convert an optical trigger pulse into an electrical signal, an inverter to generate a control signal, and control circuitry to generate local integration control signals. These control signals define the start duration and sampling period of the electrical charge generated by the photodiode. Additionally, the imager employs a trigger mechanism that produces an electrical pulse, triggering the pixels to commence an integration period. It also employs tree-type electrical distribution to propagate the electrical pulse to all pixels. What sets this technology apart is its unique mechanism of controlling the image capturing period (integration period) at a pixel level. Each pixel not only includes a global repeater circuit to propagate an electrical pulse via tree-like electrical distribution, but also a local repeater circuit to provide each local pixel array with the initial pulse edge. This technology significantly enhances the precision and control of the image capture period by governing the start duration and sampling of the electrical charge at each pixel.	Sensors- Readout & Detector Architectures	Microelectronics Laboratory
Rapid prototyping of single-photon-sensitive silicon avalanche photodiodes	11,372,119	6/28/22	Brian F. Aull, Joseph S. Ciampi, Renee D. Lambert, Christopher Leitz, Karl Alexander McIntosh, Steven Rabe, Kevin Ryu, Daniel R. Schuette, David Volfson	The developed chip-to-chip integration process radically innovates the prototyping method of silicon avalanche photodiode (APD) arrays. It considerably reduces the cost per development cycle, eliminating the need for a dedicated full-wafer readout integrated circuit (ROIC) fabrication. It also offers compatibility with ROICs made in previous fabrication runs, and accelerates schedules. The chips can be processed swiftly at the chip-level, from dicing to bump-bonding and thinning, contrasting the slower wafer-level back-illumination process. This technology stands out for its ability to provide mechanical support to the APD device via the CMOS substrate, enabling the integration of fast microlenses directly on the APD back surface. It yields APDs with lower dark count rates and higher radiation tolerance, suitable for harsh environments. Also, the process can be extended to create larger arrays of APDs.	Sensors- Readout & Detector Architectures	Microelectronics Laboratory
Geiger-Mode Avalanche Photodiode Arrays Fabricated on Silicon-on-Insulator Substrates	18/155,876	pending	Kevin Ryu, Joseph S. Ciampi, Brian F. Aull, Kevan Donlon, Renee D. Lambert	The invention refers to a method for creating avalanche photodiodes that operate in Geiger mode. These highly sensitive detectors are capable of sensing single photons, and this proposed process is for manufacturing them on a separate wafer from the readout integrated circuits (ROICs) responsible for processing the signals from the photodiodes. An epitaxial layer is grown on a semiconductor-on-insulator wafer to form the photodiode arrays, which are subsequently individualized into chips and paired with corresponding ROIC chips using bump bonding techniques. The differentiation of this technology lies in its dual-wafer approach and the use of advanced bump bonding to create highly compact, integrated devices. This architecture significantly improves the efficiency of photon detection and signal processing, enabling higher resolution imaging in various applications. The use of semiconductor-on-insulator substrates further enhances device performance by reducing electrical noise and improving isolation between components.	Sensors- Readout & Detector Architectures	Microelectronics Laboratory
CMOS readout architecture and method for photon-counting arrays	8,426,797	4/23/13	Brian F. Aull, Matthew J. Renzi, Robert K. Reich, Daniel R. Schuette	This technology involves the utilization of a complementary metal-oxide-semiconductor (CMOS) readout architecture for photon-counting arrays. This setup includes a photon-counting detector, a digital counter, and an overflow bit for every sensing element in the array. The detector, typically a Geiger-mode avalanche photodiode (APD), produces quick pulses whenever a photon is detected. These pulses increment the digital counters and once a preset count is achieved, the overflow bit is set. A rolling readout system, in operation with each sensing element, checks the overflow bit and if it's "high," initiates a data transfer to a frame store. The key distinguishing factor of this technology is its juxtaposition against other photon-counting images. It operates with a substantially decreased transfer bandwidth, allowing more data to be transferred and processed over a given period. Moreover, its high dynamic range permits capturing of images with varying degrees of light intensities within a single scene, while the fine spatial resolution allows for capturing detailed and high-quality images. These factors position it as a superior and efficient option in the field of photon-counting imagers.	Sensors- Readout & Detector Architectures	Microelectronics Laboratory
Superconducting parametric amplifier neural network	11,556,769	1/17/23	Alexander Wynn	The superconducting parametric amplification neural network (SPANN) described here integrates neurons that function within the analog domain for initial data processing and a fanout network that functions within the digital domain for subsequent activity. Each individual neuron is given one or more input currents with a bit resolution. These currents are subsequently weighted, summed, and possibly incorporated with a bias or threshold current. The system then applies a nonlinear activation function to the derived results by employing a quantum flux parametron (QFP) that allows for both simultaneous amplification and digitization of the output current signal. What differentiates this technology is its digital-to-analog operation within a single framework — allowing for the conversion of signals between analog and digital formats for efficient interpretation. This unique architecture helps to maintain the digital integrity of the information carried in currents. In addition, the use of QFP for implementing the nonlinear function ensures that the amplified output is digitized, thus providing a dual benefit.	Computing	Microelectronics Laboratory
Active Wafer-Scale Reconfigurable Logic Fabric for AI and High-Performance Embedded Computing	18/883,881	pending	Brian Tyrrell, Albert Reuther, Rabindra Das, Vitaliy Gleyzer	An active–passive wafer-scale logic fabric integrates hundreds of bare-die chips into a single, monolithic device by combining a solder-compatible under-bump metal (UBM) layer with µ-bump flip-chip bonding to heterogeneous ICs and a base interposer or PCB substrate. Multiple passive routing layers, implemented with transistor-based switches or routing chiplets, can be masklessly reconfigured to bypass defects discovered during wafer-scale testing. Through-silicon vias link the fabric's opposing surfaces, while hierarchical interconnect pitches use distinct solder or metal alloys to optimize signal integrity at each integration level. Integrated cooling structures — such as micro-channels and micro-jets—are embedded directly into the wafer, and the fabrication flow merges EX4 deep-ultraviolet (DUV) lithography for active device layers with large-field i-line reticles and stitching for interconnects up to 88 mm^2, rounded out by laser direct-write (LDW) or contact lithography to complete full-die circuitization.	Computing	Microelectronics Laboratory
Cryogenic electronic packages and methods for fabricating cryogenic electronic packages	10,381,541	8/13/19	Rabindra N. Das, Eric A. Dauler	The cryogenic electronic package consists of several key features, including a primary superconducting multi-chip module (SMCM), a secondary SMCM, a superconducting interposer, and a superconducting semiconductor structure. The assembly is arranged such that the interposer is overlaid and coupled with the primary SMCM. Then the secondary SMCM is mounted and connected to the superconducting interposer. The superconducting semiconductor structure, in turn, is placed over and attached to the secondary SMCM. Notably, the secondary SMCM and the aforementioned structure are both electrically coupled to the primary SMCM via the interposer. What sets this technology apart is the multilevel coupled superconducting system that allows effective heat dissipation and efficient electrical coupling. This unique structure enables advanced cooling technologies to enter realms of performance not possible with conventional strategies. Additionally, a method to fabricate this innovative cryogenic electronic package is proposed, further demonstrating its practical applicability and potential benefits.	Computing	Microelectronics Laboratory
Multidimensional associative array database	8,631,031	1/14/14	Jeremy V. Kepner	This technology is an associative array that stores data in matrix form to optimize linear algebra operations. In comparison to traditional models, this approach takes advantage of algebraic engines to implement standard linear algebra computations, simplifying the coding constructs and database operations. The associative arrays are not confined by rigid schemas or transaction atomicity that usually result in transactional overheads. Instead, these arrays store only non-null entries as tuples that can easily respond to linear algebra operations. What sets this technology apart is its inherent flexibility and diminished dependence on global consistency or transaction atomicity for retrieving useful results. The relaxing of consistency recognizes that many database queries are aimed at retrieving data that often change over time. In contrast to traditional models like SQL, this technology greatly reduces the complexity and cost associated with maintaining and processing database operations.	Computing	Microelectronics Laboratory
EXtreme virtual memory	9,852,079	12/26/17	Jeremy Kepner, Hahn Kim, Crystal Kahn	This technology presents a method and computer program product for managing and distributing parallel data across a parallel hierarchical storage system. It works by utilizing a hierarchical map of the parallel data that consists of multiple map objects. Each of these map objects provides intricate details on how to partition a given array of data into multiple subarrays. This data partitioning is outlined by a parent map object of the map object. The technology also clearly describes how to store the parallel data into the computer's parallel storage hierarchy. This unique approach to data organization and distribution differentiates this technology from others. The use of a hierarchical map to manage and control data distribution across storage systems provides tremendous efficiency, scalability, and organization to enable the handling of large data sets in a structured manner. This programmatic approach to data storage ensures the right segregation of data into subarrays, enabling faster data retrieval and processing.	Computing	Microelectronics Laboratory
Systolic merge sorter	8,190,943	5/29/12	William S. Song	The technology is a sorter system comprising a clock, a systolic array circuit, and control circuitry. The clock generates a series of uninterrupted signals. The systolic array circuit includes a minimum of one processing module and K-1 registers, where K is an integer greater than two. Each processing module possesses at least one of the registers, with each data item stored in one register. The control circuitry is in communication with a serial access memory, which stores data items to be sorted. It supplies data items to, and receives them from, the systolic array system as input and output respectively. What sets this technology apart is its ability to present K data items for input to the systolic array circuit in synchronization with the clock signals. This ability means that on the next clock cycle after the control circuitry presents the last of the K data items, the least valuable data item in the given subsequence is automatically output, exceptionally improving the sorting efficiency of data processing systems.	Computing	Microelectronics Laboratory

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Patent title, as issued	Patent Number	Date issued	Inventor name(s)	Brief Description of Patent (Claims/Field of Use)	Technology area subfields	Facilities available that may support continued R&D
Cube coordinate subspaces for nonlinear digital predistortion	7,808,315	10/5/10	Joel I. Goodman, Benjamin A. Miller, Matthew A. Herman	This invention encompasses a method for handling a mathematical approach that enables efficient search for and identification of particular regions in a multidimensional signal space. Using this approach, the inversion of power amplifier nonlinearities is enabled with a remarkable reduction in computational complexity, making its hardware implementation more manageable and efficient. It specializes in linearizing a wideband power amplifier by representing its response with certain coefficients within a cube coefficient subspace and subsequently performing a search over the full multidimensional subspace. This technology stands out because of its ability to identify a vector of cube coefficient subspace coefficients. These identified coefficients are then used to linearize the wideband power amplifier. This innovative approach, therefore, greatly simplifies and expedites the process of wideband power amplifier linearization while keeping the computational complexity at a minimum. This realization of maximizing efficiency and reducing resources distinguishes the technology from the existing solutions in the market.	Communication Devices- RF & Wireless Communications	Microelectronics Laboratory, RF Systen
Compact model nonlinear compensation of bandlimited receiver systems	10,666,307	5/26/20	Xiao-Yu Wang	This technology is a nonlinear compensator made up of a decomposition circuit and several filtering elements. The decomposition circuit, rigged to receive an input signal, has a nonlinear frequency response characteristic. It works to decompose the input signal into its corresponding positive and negative frequency signal components. After decomposition, each filter element receives portions of the decomposed signals, matching these with the nonlinear frequency response of the decomposition circuit and then further refining them. What distinguishes this technology is its novel approach to signal compensation. By integrating a decomposition circuit with filter elements, the system allows for more effective filtering of separated positive and negative frequency components. This two-tiered process enables much better control and adjustment of signals, making it an advanced solution for signal handling.	Communication Devices- RF & Wireless Communications	Microelectronics Laboratory, RF Systen
Analog/digital co-design methodology to achieve high linearity and low power dissipation in a radio frequency (RF) receiver	8,964,901	2/24/15	Helen Kim, Merlin Green, Andrew Bolstad, Daniel D. Santiago, Michael N. Ericson, Karen Gettings, Benjamin A. Miller	This technology centers around developing radio frequency (RF) receiver design techniques. It approaches the design process holistically, considering in unison both the components of an analog receiver chain and digital nonlinearity mitigation methods. This unified consideration during design results in a highly efficient and linear RF receiver. A key advantage lies in power conservation, as the combined front-end technique leads to significantly reduced power usage in the receiver. What sets this technology apart is its hybrid approach, merging both analog and digital aspects during the design process. While individual components such as the analog receiver chain and digital nonlinearity compensation have their own energy benefits, the combined design brings about enhanced efficiency. This technology achieves linearitization without prejudicing power exertion, thus innovatively balancing the traditionally precarious trade-off between performance integrity and energy utilization.	Communication Devices- RF & Wireless Communications	Microelectronics Laboratory, RF Systen
Accurate timing distribution by high-frequency radio	10,148,345	12/4/18	Frank C. Robey	This advancement is a procedure for determining an absolute time reference for high-frequency (HF) sounding signals. It includes transmitting a reference signal from a location, alongside a sounding signal. Both of these signals are then received at a second location. The innovative factor lies in utilizing the received signals to determine relative delay of the sounding signal to the reference signal and ascertain the propagation mode based on this delay. What sets this technology apart is the ability to interpret the absolute time reference on the basis of the identified propagation mode. Existing systems do not have this nuanced approach for calculating the precise timing reference by correlating sounding signals with reference signals. This approach results in a more accurate reading and understanding of high-frequency signal behavior.	Communication Devices- RF & Wireless Communications	Microelectronics Laboratory, RF Systen
Method and apparatus for smart adaptive dynamic range multiuser detection radio receiver	10,686,513	6/16/20	Rachel E. Learned, Paul D. Fiore	This technology uses a uniquely designed receiver that includes functions like multiuser detection (MUD) and a cognitive engine. The receiver can be coupled to multiple antennas and possesses an analog beamforming capability. The cognitive engine's primary role is to select suitable beams, connected to these multiple antennas, to enable successful demodulation by the MUD. It's designed for use in multiple access channels and other communication scenarios. What makes this technology distinctly advanced is the optimal combination of MUD functionality and a cognitive engine. The former allows the receiver to effectively handle data from multiple users simultaneously while the latter intelligently selects the best beam or beams for this process. Combined with the analog beamforming ability, tis receiver enables more efficient data processing and communication, making it versatile and adaptive to various scenarios.	Communication Devices- RF & Wireless Communications	Microelectronics Laboratory, RF Systen
Multiuser detection for high capacity cellular downlink	10,051,616	8/14/18	William S. Song, Adam R. Margetts	This technology is a system and a method designed for precisely decoding an intended transmission. The system involves a user device that receives a downlink transmission containing a signal meant for that device and other overlapping or interfering user signals directed at other devices. Essential to this system is a method of power stacking to carry data about the power level of each user signal in the received downlink transmission. Pilot signals in the downlink transmission serve as a basis for estimating the channel. What differentiates this technology is its capability to efficiently demodulate and decode each interfering user signal using the power stacking information, thus accurately distinguishing between them. As a result, all interfering signals can be effectively removed from the received downlink transmission, leaving intact only the signal intended for the user device. This system assures precise signal reception amid heavy interference.	Communication Devices- RF & Wireless Communications	Microelectronics Laboratory, RF Systen
Power amplifier operation	10,541,658	1/21/20	Andrew H. Zai, Michael D. Lockard, Kenneth E. Kolodziej, Jeffrey S. Herd	This new system focuses on advanced power amplifier operation. It is composed of a baseband signal generator linked with a baseband signal digital-to-analog converter and several power amplifiers. These power amplifiers are linked with a shared envelope signal generator connected to an envelope signal digital-to-analog converter. Furthermore, a supply modulator is connected to the envelope signal digital-to-analog converter and the power amplifiers. The advantage of this technology comes from its shared envelope tracking across multiple power amplifiers. This unique feature allows for increased efficiency in the power amplification process. Through this, the system optimizes power delivery, reduces power waste, and enhances the functionality of the connected devices.	Communication Devices- RF & Wireless Communications	Microelectronics Laboratory, RF Systen
Method and apparatus for determining a receiver beam in a co-existence cognitive radio	11,637,613	4/25/23	Rachel E. Learned	This technology is a method to mitigate interference in a communication channel populated by multiple users. The method determines a starting angle based on the direction of a desired signal of interest (SOI). It then steers a beam away from this starting angle in opposite directions on an iterative basis, calculating a grade for each new orientation of the beam. The beam at the grade-assessed angle is chosen as the receiving beam, which then receives the signal. Finally, the SOI is decoded from the one or more interfering signals using a technique known as successive interference cancellation multi-user detection (SIC MUD). The distinguishing feature of this technology is its novel approach in handling channel interference. By iteratively steering a beam and employing SIC MUD, the technology offers efficient interference mitigation. This approach ensures that beam steering is not locked into a single, potentially obstructed direction, thereby optimizing signal reception. The application of SIC MUD as a final decoding step enhances the overall multi-user interference mitigation, making this method a novel solution to interference.	Communication Devices- RF & Wireless Communications	Microelectronics Laboratory, RF Systen
Method and apparatus for complex in-phase/quadrature polyphase nonlinear equalization	8,705,604	4/22/14	Joel I. Goodman, Benjamin A. Miller, Matthew A. Herman, James Edwin Vian	Complex polyphase nonlinear equalizers (cpNLEQs) serve as a corrective tool for distortions generated by complex in-phase/quadrature (I/Q) time-interleaved analog-to-digital converters (TiADCs). The cpNLEQs upsample the digital waveform produced by the TiADC, for example, by a factor of two, thereafter separating it into upsampled in-phase and quadrature components. Processors within the cpNLEQs manufacture real and imaginary nonlinear compensation terms from these upsampled elements. The standout features of cpNLEQs rest in their ability to downsample the compensation terms, phase-shift the downsampled imaginary component, and combine it with the downsampled real component. This process produces an estimated residual distortion. Subtraction of this distortion from the originating digital waveform emitted by TiADC results in an equalized digital waveform fit for further processing, setting cpNLEQs apart by materially enhancing the quality and reliability of digital waveforms.	Communication Devices- RF & Wireless Communications	Microelectronics Laboratory, RF Systen
Adaptive digital cancellation using probe waveforms	1,022,511	3/5/19	Jonathan P. Doane	This technology consists of a method and an apparatus that use digital cancelling based on probe waveforms to perform simultaneous transmitting and receiving functions. The mechanism involves transmitting and receiving correlated signals in adjacent channels. The mechanism is enabled by the probe waveforms that facilitate the effective cancellation of any disruption or interference between the channel operations. What sets this technology apart is its digitally engineered cancelling ability that allows for adjacent channels to operate concurrently without interference, thereby enhancing the efficiency and speed of data transmission. The use of probe waveforms in conjunction with digital cancelling addresses the high demand for multichannel simultaneous operations, thereby providing a unique and high-performing solution for communication networks.	Communication Devices- RF & Wireless Communications	Microelectronics Laboratory, RF Systen
Equalization of receiver	10,348,345	7/9/19	Matthew C. Guyton, Xiao Wang	This invention includes methods and systems built to equalize reception in a first receiver. It involves receiving an input signal at two different receivers and then assessing the second receiver's output response to estimate an out-of-channel interferer present in the input signal. Furthermore, it entails determining an estimate of the undesired in-channel response of the first receiver to the out-of-channel interferer within the input signal. The inventive aspect of the system is the mode of application by which the estimate of the undesired in-channel response of the first receiver to the out-of-channel interferer present in the input signal is applied to an output signal of the first receiver to substantial cancellation of any undesirable in-channel response stemming from out-of-channel interference. This solution proves to mitigate signal disruption.	Communication Devices- RF & Wireless Communications	Microelectronics Laboratory, RF Systen
Message fractionation and physical layer channel assignment for multiuser detection-enabled wireless communication among adaptive interference	10,159,004	12/18/18	Rachel E. Learned, Prabahan Basu	Cognitive coexistence radio is an advanced technology that leverages the principle of message fractionation and physical layer channel assignment. It aims to establish coexistence communications amidst potential interferers. The technology breaks a transmit signal into multiple streams, directing them for transmission via occupied channels by proper power allocation and modulation scheme. It employs a near-optimal selfish power-allocation method rooted in the "water-filling" solution, a popular method to maximize signal-to-noise ratio in telecommunications. What sets this technology apart from others is its ability to function amidst interference. It could utilize occupied channels by dispersing the transmit signal into multiple streams based on the detailed power-allocation and -modulation scheme. This approach ensures the most efficient use of available resources, especially in crowded spectrum environments. Furthermore, the use of the water-filling solution promotes an increased capability in power management to maintain signal integrity and noise suppression.	Communication Devices- RF & Wireless Communications	Microelectronics Laboratory, RF Systen
Method and apparatus for making optimal use of an asymmetric interference channel in wireless communication systems	9,148,804	9/29/15	Rachel E. Learned	A method and apparatus for transmitting and receiving in black space is described. The asymmetric interference channel is an appropriate model for many realistic scenarios, especially those arising more frequently as dynamic spectrum access (DSA) becomes more prevalent. As DSA nodes evolve to become more cognitive (e.g. self aware, environment aware, and adaptive), the prevailing white space seeking and gray space adapting policies leave a significant portion of the spectrum, namely, the black space, untapped. Described herein is a throughput versus SINR result and a corresponding technique for jointly choosing a transmission rate and multiuser detection algorithm that allows computationally constrained cognitive DSA nodes high rate operation in spectrum black space. Also described is an information theoretic motivated policy for seemingly insignificant waveform design choices that greatly enhance the throughput of a secondary sender-receiver pair while fulfilling a given complexity requirement within the secondary node's receiver.	Communication Devices- RF & Wireless Communications	Microelectronics Laboratory, RF Systen
High-throughput wireless communications encoded using radar waveforms	11,181,630	11/23/21	Ian Weiner	The innovation is a high-throughput communication channel using specially formulated transmit waveforms. These waveforms address technical constraints that are considered crucial to ensure the effectiveness of radar operations and signal processing. Thus, it not only enhances communication speed but also ensures the accuracy of radar functions. The utility of this technology goes beyond these primary features as it also introduces cooperative spectrum sharing. Radar and communications systems traditionally function on different spectrums, sometimes creating obstacles in communications. This invention paves the way for these systems to share a common spectrum, effectively reducing interference and boosting the overall performance and efficiency of both radar and communications systems.	Communication Devices- RF & Wireless Communications	Microelectronics Laboratory, RF Systen
Compact model nonlinear compensation of bandlimited receiver systems	10,666,307	5/26/20	Xiao-Yu Wang	This technology is a nonlinear compensator made up of a decomposition circuit and several filtering elements. The decomposition circuit, rigged to receive an input signal, has a nonlinear frequency response characteristic. It works to decompose the input signal into its corresponding positive and negative frequency signal components. After decomposition, each filter element receives portions of the decomposed signals, matching these with the nonlinear frequency response of the decomposition circuit and then further refining them. What distinguishes this technology is its novel approach to signal compensation. By integrating a decomposition circuit with filter elements, the system allows for more effective filtering of separated positive and negative frequency components. This two-tiered process enables much better control and adjustment of signals, making it an advanced solution for signal handling.	Communication Devices- RF & Wireless Communications	Microelectronics Laboratory, RF Systen
Methods and systems for signal interference cancellation	11,611,423	3/24/22	Kenneth E. Kolodziej	A system for canceling signal interference (SI) includes a transceiver configured to concurrently transmit signals and receive signals within a single frequency band, which causes signal interference between the transmitted and received signals. The SI canceller is configured to use a set of cancellation coefficients to generate a cancellation signal to mitigate the SI. The system is configured to iteratively change the cancellation coefficients by a step factor to produce tuned cancellation coefficients. The step factor is determined by a cancellation error gradient and one or more of: a tunable coefficient step aggressiveness factor; and a time-based forgetting factor; and cause the SI canceller to cancel the SI using the tuned cancellation coefficients.	Communication Devices- RF & Wireless Communications	Microelectronics Laboratory, RF Systen

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Patent title, as issued	Patent Number	Date issued	Inventor name(s)	Brief Description of Patent (Claims/Field of Use)	Technology area subfields	Facilities available that may support continued R&D
Process for low-loss dielectric and related structures	18/842,858	pending	William D. Oliver, Alexander J. Melville, Wayne H. Woods, Jonilyn L. Yoder, Sergey K. Tolpygo, Mollie E. Schwartz, Evan B. Golden, David K. Kim, Kyle A. Serniak, Bethany Niedzielski Huffman, Arjan Sevi	The technology utilizes advanced fabrication methods to create low-loss, high-specific-capacitance parallel-plate capacitors (PPCs) optimized for superconducting quantum devices. By employing aluminum oxide (AlOx) as the dielectric material, the capacitors achieve superior loss characteristics. The fabrication process involves shadow-evaporation techniques, such as the Dolan bridge, which allow for the deposition of ultrathin AlOx layers between 5 and 10 nm. This precise control of dielectric thickness minimizes dielectric volume, effectively reducing two-level systems' density, a common source of loss in quantum devices. The process is compatible with various qubit-fabrication methods and is implemented on high-resistivity silicon substrates, ensuring uniformity and scalability across large wafers.	Communication Devices- RF & Wireless Communications	Microelectronics Laboratory, RF Systen
Coincident phase centered flared notch feed	10,505,281	12/10/19	Glenn A. Brigham	The invention is a coincident phase-centered antenna with four prongs independently fed by unique conductors. Each conductor is connected with a connector or trace situated on the underside of the base or affiliated printed circuit board. The design enables the provision of independent signals to all four prongs in this antenna. Also, in some of the design versions, the prongs are installed on a metal base, while in others, they are fastened on a printed circuit board. The technology's differentiation lies in its capability to independently supply signals to each prong, enhancing the flexibility of use and application. The conductors can either be linked to a connector or trace on a metal base or a printed circuit board, offering a range of possible configurations. The high-volume, flexibility, and ease of use offer significant advantages over conventional antenna systems.	Communication Devices- Antenna	Microelectronics Laboratory, RF Systen
Fiber Based RF Phased-Array Antennas	18/199,564	pending	Alan J. Fenn, Alexander Stolyarov, Siva Yegnanarayanan, Lauren Cantley	The invention details a flexible thermally drawn receive phased array antenna system constructed using polyetherimide (PEI) fiber material to enhance pliability and durability. It consists of multiple antenna elements and integrated low-noise amplifiers (LNAs), which are beneficial for signal clarity and strength. An innovative aspect includes the encapsulation of the critical components within the fiber, with electrical wires also enclosed to provide a DC bias to the LNAs. The array's dipole antenna elements are designed to function at ultrahigh frequencies (UHF), providing a wide range of applications. This flexibility introduces a transformative capability for the antenna system because it can conform to various surfaces and shapes. This characteristic stands out compared to traditional rigid phased array antennas, thereby allowing for more versatile installation options and potentially more inconspicuous deployment in various environments.	Communication Devices- Antenna	Microelectronics Laboratory, RF Systen
Compact steerable transmit antenna system	10,211,531	2/19/19	Robert Galejs	The technology is a transmit antenna system configured to steer electromagnetic beams. The system is composed of three antenna elements: a first and second electric antenna both aligned parallel to a first plane, with the second oriented perpendicularly to the first, and a magnetically oriented antenna element also perpendicular to the first and second elements. The electronic steering module maintains electrical communication with all three antenna elements. What differentiates this system is its electronic steering module that includes at least one amplifier designed to control the current's amplitude to each antenna element. Through this unique mechanism, the system achieves unparalleled precision in the manipulation and direction of electromagnetic beams. The well-orchestrated interplay between these different elements allows the system to achieve a superior beam steering capability.	Communication Devices- Antenna	Microelectronics Laboratory, RF Systen
Targeted ratio of signal power to interference plus noise power for enhancement of a multi-user detection receiver	11,005,507	5/11/21	Michael Dowling	The invention is a method for identifying a beam in a multi-user detection (MUD) receiver that produces a specific signal-to-interference-plus-noise ratio (SINR). The process involves determining a maximum output SINR and beam weights that can achieve the target SINR using the maximum output SINR. These beam weights are then applied to received signals that may contain an intended signal, interfering signals, and noise to generate a beamformed signal with the desired SINR. One of the key differentiators of this technology is its approach to signal detection and recovery in a noisy environment. The technology determines beam weights to achieve the target SINR and applies these weights to filter out the noise and interference, thereby generating an optimized, beamformed signal that ensures better signal recovery in multi-user detection units.	Communication Devices- Antenna	Microelectronics Laboratory, RF Systen
Digital matching of a radio frequency antenna	9,825,659	11/21/17	Frank C. Robey, Timothy M. Hancock, Gregory B. Stahl	This technology consists of a method and an apparatus that use digital cancelling based on probe waveforms to perform simultaneous transmitting and receiving functions. The mechanism involves transmitting and receiving correlated signals in adjacent channels. The mechanism is enabled by the probe waveforms that facilitate the effective cancellation of any disruption or interference between the channel operations. What sets this technology apart is its digitally engineered cancelling ability that allows for adjacent channels to operate concurrently without interference, thereby enhancing the efficiency and speed of data transmission. The use of probe waveforms in conjunction with digital cancelling addresses the high demand for multichannel simultaneous operations, thereby providing a unique and high-performing solution for communication networks.	Communication Devices- Antenna	Microelectronics Laboratory, RF Systen
Auxiliary antenna array for wideband sidelobe cancellation	10,476,154	11/12/19	Jonathan Peter DOANE, Glenn A. Brigham, Bradley T. Perry	This sidelobe cancellation system specifically designed for simultaneous transmit and receive (STAR) systems. It boasts a primary aperture array complemented by an auxiliary array that has antenna elements positioned adjacent to the primary aperture. The auxiliary array components are coupled to either a variable attenuator, a variable phase shifter, or a variable true time-delay unit. A controller is used to adaptively tune the auxiliary array by selecting appropriate values of attenuation, phase shift, and time delay for each of its elements. This optimization effectively cancels out the sidelobes of the primary aperture. The technology stands out for its adaptive nature and sophistication. Each antenna element in the auxiliary array performs as an adaptive tap of an adaptive finite-impulse response (FIR) filter. The system's adaptive capabilities are derived from the integration of the variable attenuator, phase shifter, and time delay unit for each element of the auxiliary array, making it an effective and precise solution for sidelobe cancellation.	Communication Devices- Antenna	Microelectronics Laboratory, RF Systen
Wideband simultaneous transmit and receive (STAR) antenna with miniaturized TEM horn elements	9,847,582	12/19/17	William F. Moulder, Bradley T. Perry, Jeffrey S. Herd	The antenna system in question is aimed at facilitating simultaneous transmitting and receiving (STAR) operations over a large bandwidth. Its unique structure incorporates a ring array of TEM horn elements and a centrally situated monocone or bicone antenna. Each of the TEM horn elements includes a unique feature - a capacitive feed. The distinct elements of the ring array are triggered using a phasing scheme aimed at causing signal cancellation at the location of the central element. This ring array can play a dual role, serving either as the transmitting antenna or the receiving antenna. The antenna system stands out due to its unique operative capacity - simultaneous transmit and receive (STAR) in wide bandwidth situations. Thanks to the specialized phasing scheme, signal cancellation is a key feature here, focusing on the central antenna element. This system's flexibility is a significant attribute, with the ring array able to switch roles between transmitting and receiving antenna. This dual functionality renders it distinct in the sphere of such technologies.	Communication Devices- Antenna	Microelectronics Laboratory, RF Systen
Compact cavity-backed discone array	11,121,473	9/14/21	Adam J. Chapman, Alan J. Fenn, Pierre Dufilie	This technology is a compact, shallow, cavity-backed discone antenna array designed for conformal omnidirectional antenna applications. The system features a group of discone antennas positioned in a ring array within a conical cavity. This cavity is sealed with an electrically transparent radome. Coaxial transmission lines feed each individual antenna element. The antenna array boasts excellent performance,as evident from simulation and experimental results, particularly in terms of reflection coefficient and omnidirectional gain radiation patterns that span frequencies from 960 to 1220 MHz. The uniqueness of this technology is its compactness coupled with its conformal nature, allowing installation onto tight spaces, such as the outer mold line of any aircraft. The use of the discone antenna array enhances performance across the specified frequency range. Its compactness ensures that it doesn't protrude much from the aircraft body, minimizing aerodynamic interference.	Communication Devices- Antenna	Microelectronics Laboratory, RF Systen
Stacked patch antenna array with castellated substrate	10,236,593	3/19/19	Pierre A. Dufilie, Jeffrey S. Herd	The technology is a unique design for a printed circuit antenna array that integrates at least one layer of castellated substrate. This configuration serves to improve signal strength, quality, and range by ensuring optimal electrical paths. The technology further includes a stacked patch antenna array, which contributes to the directional characteristics of the antenna, improving its ability to focus and transmit signals. What sets this technology apart is the use of a castellated substrate in its design, a feature that is relatively uncommon in current antenna configurations. By creating a castellated structure, the technology ensures optimal electrical paths, improving reliability and reducing signal loss or distortion. Additionally, the stacked patch antenna array can provide better directional control of the signal, improving the antenna's performance even in cluttered or difficult signal environments.	Communication Devices- Antenna	Microelectronics Laboratory, RF Systen
Multi-fin flared radiator	10,193,237	1/29/19	Glenn A. Brigham	In this flared antenna, the upper part of the antenna prongs divide into several parallel fins. These parallel fins situated on the energized prong are provided power by a collective electrical feed source, such as a coaxial transmission line that extends into the energization region of the prong. The flared antenna might be a Vivaldi antenna, a stepped notch antenna, or any other flared shape. The unique aspect of this technology lies in the application of separate fins to expand the level of tuning, enriching both BW and scan performance for a given equivalent design. The individual design of each fin pair aids in the optimization of these improvements, allowing them to function independently of each other. This design eliminates dependencies and enhances the performance of the flared antenna.	Communication Devices- Antenna	Microelectronics Laboratory, RF Systen
Foam radiator	10,950,929	3/16/21	Glenn A. Brigham	This technology presents a unique way of crafting a lightweight antenna by using foam material that is strategically coated with a machinable material and later plated with metal. This method enables an effective radiator with dimensions and performance equivalent to traditional notch antennas but with significantly less weight. Mountable on a variety of substrates, embodiments of the technology can utilize mixed or multilayered foam substrates, including conventional printed circuit boards (PCBs), PCBs with sleeved coaxial vias, or foam substrates. What sets this technology apart is its response to the need for lightweight, versatile antennas, particularly in ultrawideband array systems and space-based applications. The incorporation of foam and metal-plated materials offers less weight without compromising performance, making it an ideal solution for applications for which weight comes at a premium. The invention's ability to be mounted on an array of substrates further enhances its flexibility and potential for widespread utilization.	Communication Devices- Antenna	Microelectronics Laboratory, RF Systen
Integrated coaxial notch antenna feed	10,541,467	1/23/20	Glenn A. Brigham, David M. Bragdon, Edward M. Froehlich	This unique system changes the traditional way notch antenna elements are supported and utilized, enabling the creation of more powerful ultrawideband step-notch arrays. The system facilitates advanced electrical connections for each of the notch antenna elements through respective coaxial cables or alternative direct connections. This innovative approach replaces the printed circuit board usually employed, leading to significant increases in power delivery. What differentiates this technology is its ability to deliver higher power to the notch antenna elements more efficiently than conventional methods. The paradigm shift of replacing the printed circuit board with direct connections via coaxial cables results in higher power and increased durability. More so, it offers a new way of arranging and deploying antenna elements, improving performance across the board and demonstrating a substantial evolution from traditional antenna technology.	Communication Devices- Antenna	Microelectronics Laboratory, RF Systen
Printed circuit board assembly with foam dielectric material	10,249,943	4/2/19	Glenn A. Brigham	An assembly that includes a printed circuit board and a foam dielectric material, and a method of fabricating the assembly is disclosed. The assembly includes at least one layer of a foam dielectric material, which has properties similar to those of air. This layer of foam dielectric material is disposed between a top subluminate and a bottom subluminate. The bottom subluminate may be a traditional printed circuit board, comprising an arbitrary number of layers. The top subluminate may be a single layer, or may be multiple layers and may include an antenna. The foam dielectric material serves to provide mechanical support for the top subluminate and the central conductor. The foam dielectric material also provides physical separation between the bottom subluminate and the antenna.	Communication Devices- Antenna	Microelectronics Laboratory, RF Systen
Miniature ultra-wideband multifunctional antennas and related techniques	10,498,017	12/3/19	Raoul Ouatagom Ouedraogo, Eric Phelps, Jeremy Muldavin, Todd Addison Thorsen, Carl O. Bozler, Christopher CHERRY	Miniature multifunctional antennas and related techniques are disclosed that are capable of wide bandwidth operation. In some embodiments, the antennas are capable of being reconfigured in the field for optimal performance in different frequency band configurations (e.g., a single wide instantaneous bandwidth, multiple smaller bands, etc.) and/or for purposes of self healing. In some embodiments, the antennas can be reconfigured in the field to achieve different polarizations (e.g., vertical, horizontal, circular). The antennas can be implemented in a very compact manner making them ideal for use in devices and platforms where size and weight are a concern.	Communication Devices- Antenna	Microelectronics Laboratory, RF Systen

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Patent title, as issued	Patent Number	Date issued	Inventor name(s)	Brief Description of Patent (Claims/Field of Use)	Technology area subfields	Facilities available that may support continued R&D
Sidelobe detector and angle/angle-rate estimator for a slewing monopulse antenna	11,402,488	8/2/22	Andrew L. Kintz	The presented technology is a system and method that allows for an accurate estimation of both the angle and the angle rate for a particular target by using a slewing antenna. The system uses a unique form of noncoherent integration that can extend to estimate a target's angle rates. Furthermore, this advanced method can potentially expand to discern if a target is located in the main beam or a side lobe in one or dual directions. What makes this particular technology stand out is its sophisticated use of noncoherent integration to ascertain the angle and angle rates of a target. Unlike other systems and methods, this technology can differentiate main lobe and side lobe targets, a function highly beneficial in signal processing and object tracking to enhance the accuracy and efficiency of object detection and tracking.	Communication Devices- Antenna	Microelectronics Laboratory, RF Systen
Simultaneous transmit and receive antenna system	8,749,441	6/10/14	Alan J. Fenn, Peter T. Hurst, Jeffrey S. Herd, Kenneth E. Kolodziej, Leonard I. Parad, Hans Steyskal	The technology is a simultaneous transmit and receive antenna system comprising a ring array either filled with transmit antenna elements or receive elements. A separate antenna element lies on an axis that passes through the center of the ring array and is perpendicular to it. In each configuration, the antenna elements opposite each other in the ring array possess a phase difference of 180° to create a radiation pattern null at the antenna on the axis running through the center of the array. This arrangement ensures high interference isolation. Its unique construction allows for a high degree of isolation between the transmit and receive elements, achieved by having at least one ground plane and an electrically conductive cylinder positioned on the perpendicular axis inside the ring array. This advanced configuration allows the system to be compatible for wireless data transmission following well-known wireless communication standards, such as WIFI IEEE standard 802.11 or WIMAX IEEE standard 802.16.	Communication Devices- Antenna	Microelectronics Laboratory, RF Systen
Multipolarized vector sensor array antenna system for search and rescue applications	10,416,268	9/17/19	Alan J. Fenn, Beijia Zhang, Peter T. Hurst, Kenneth E. Kolodziej, Larry L. RETHERFORD, Christian D. AUSTIN	This technology is a direction-finding (DF) system designed for the detection and geolocation of radio-frequency signals in two dimensions: azimuth and elevation. The DF system consists of an assembly of multipolarized loop antennas connected to a beamformer that emits monopole, dipole, and loop antenna element modal signals. A multichannel digital receiver system, also a part of the DF system, is configured to accept modal signals from the beamformer. What distinguishes this technology from others is its multipolarized antenna array that amplifies the precision of detecting RF signals, including emergency beacon sources. It provides two-dimensional geolocation, enabling highly accurate location tracking within the azimuth and elevation planes. The inclusion of a multichannel digital receiver to receive and process modal signals further enhances the system's detection capabilities, making it an effective solution for diverse applications.	Communication Devices- Antenna	Microelectronics Laboratory, RF Systen
Simultaneous transmit and receive with digital phased arrays	10,419,062	9/17/19	Jonathan P. Doane, Kenneth E. Kolodziej, Bradley T. Perry	In-band full-duplex (IBFD) technology that enables systems to transmit and receive on the same frequency at the same time has the potential for increasing the capacity and capability of wireless networks. However, IBFD systems have relied on antennas that radiate omnidirectionally and thus limit the range and number of devices a system can accommodate. Engineers at Lincoln Laboratory demonstrated IBFD technology that, for the first time, can operate on phased array antennas, which direct communication signals to targeted areas, expanding the distances that the RF signals reach and significantly increasing the number of devices connected to a single node. A demonstration system operated at 2.4 to 2.5 GHz, and a new prototype capable of 2.7 to 3.5 GHz operation is in development.	Communication Devices- Antenna	Microelectronics Laboratory, RF Systen
Physical layer encryption using out-phased array linearized signaling	10,225,039	3/5/19	Eric R. Tollefson, Bruce R. Jordan, Jr.	This technology is a system and technique for a physical layer encryption using beamforming to provide secure communications. It utilizes the principle of linear amplification with nonlinear components (LINC) to produce a transmit signal with a limited dynamic range, thus creating a more controlled, secure means of transmission. The key feature of this technology is the generation of a masking signal based on the source data signal to aid in producing a transmit signal with limited dynamic range while ensuring a high degree of secrecy. Unlike traditional encryption techniques, this approach incorporates the actual physical layer in the encryption process to add an additional layer of security. The approach of utilizing beamforming for improved signal strength and reception, paired with the LINC technique that limits the dynamic range of the signal, makes it unique. The generation of a masking signal from the source data also greatly enhances the security of the transmitted information.	Communication Devices- Antenna	Microelectronics Laboratory, RF Systen
Multipolarized vector sensor array antenna system for radio astronomy applications	10,826,199	11/3/20	Alan J. Fenn, Frank C. Robey, Peter T. Hurst, Mark J. Silver, Joseph M. D'Arco	The invention is an electromagnetic field vector sensing receive antenna array system that can be easily installed and deployed on a variety of structures. The system uses a multipolarized array of collocated antenna elements to generate precise amplitude and phase radiation patterns with monopole, dipole, and loop modes. The key system components of this unique receive antenna array system include deployable antennas, receivers, a signal processing computer, and a communications link. What sets this technology apart is its ability to detect and locate radio-frequency emissions from galactic sources, making it highly valuable in the field of radio astronomy. The integrity of the multipolarized vector sensor antenna array aids in achieving calibrated radio-frequency sensing. This capability, combined with the system's versatility of installation possibilities, such as towers, balloons, or satellites, makes this technology highly innovative and efficient for astrophysical data collection.	Communication Devices- Antenna	Microelectronics Laboratory, RF Systen
A radio system using a phase-reconfigurable reflectarray for adaptive beamforming	18/517,727	pending	David W. Browne, Swaroop Appadwedula, Christian D. Chapman, Keith W. Forsythe, Gary F. Hatke, Benjamin R. Guerriero, William F. Moulder, Navid Yazdani	The system employs a streamlined architecture featuring a single radio receiver frontend combined with a phase-reconfigurable reflectarray and an antenna. This arrangement enables the formation of directional beams toward desired signal sources while simultaneously creating nulls to suppress incoming interference. Each reflector element within the reflectarray can be individually adjusted with specific phase-shift states, allowing for the constructive combination of target signals and the destructive cancellation of unwanted ones before the signals reach the receiver frontend. The radio unit integrates essential components such as an RF-to-baseband converter, processors for array estimation and beamforming, a control unit for reflectarray configuration, and a dedicated signal processor for specialized tasks. Operationally, the system can optimize performance through iterative phase-state exploration or a two-phase online-offline estimation approach, enhancing its adaptability in dynamic environments.	Communication Devices- Antenna	Microelectronics Laboratory, RF Systen
Heteroepitaxially Integrated Compound Semiconductor Optical Devices with On-Chip Waveguides	18/317,597	pending	Christopher Heidelberger, Cheryl Marie Sorace-Agaska, rJason PLANTB, oris Kharas, Reuel B. Swint, Yifei Li, Paul William Juodawlkis	This technology is a III-V/SiNx hybrid integrated photonics platform, featuring a wafer that integrates SiNx waveguides and III-V waveguides heteroepitaxially grown from the silicon substrate. These waveguides are lithographically formed to butt couple seamlessly, resulting in efficient optical coupling with a loss transition as low as ~2.5 dB. The platform's novel approach to aligning different waveguide materials enables enhanced data transmission efficiency in photonic circuits. This platform differentiates itself through a threading dislocation density (TDD) of as low as 4×106 cm−2 in the III-V waveguides. The low TDD is critical as it permits the parallel fabrication of integrated III-V optoelectronic devices, enabling the creation of complex photonic integrated circuits with multiple active components. The improved TDD opens possibilities for higher quality and performance in a variety of optoelectronic applications.	Communication Devices- Optical & Photonic Communications	Optical Terminal Verification Testbed
Amorphous germanium waveguides for spectroscopic sensing and data communication applications	11,604,147	3/14/23	Eveline Postelnicu, Samarth Aggarwal, Kazumi WadaJurgen Michel, Lionel C. Kimerling, Michelle L. Clark, Anuradha M. Agarwal	This technology is related to the creation of a layer of amorphous germanium (Ge), formed on a substrate with a minimum thickness of 50 nm and a minimum purity of 90% Ge. The creation process involves electron-beam evaporation and is performed at room temperature. The substrate is CMOS compatible and transparent at LWIR wavelengths. This layer of amorphous Ge serves as a waveguide useful in chemical sensing and data communication applications. What makes this technology distinct is the fact that the Ge waveguide exhibits a low transmission loss within the LWIR region, specifically 11 dB/cm or less at 8 µm. This high performance makes the technology much more efficient in applications like data communication and chemical sensing, where loss in transmission could be critical.	Communication Devices- Optical & Photonic Communications	Optical Terminal Verification Testbed
Wide-area sensing of amplitude modulated signals	11,375,146	6/28/22	Kenneth Schultz	Amplitude-modulated (AM) signals spanning a spatial wide area can be efficiently detected using a slowly scanning optical system. The system decouples the AM carrier from the AM signal bandwidth (or carrier uncertainty), enabling Nyquist sampling of only the information-bearing AM signal (or the known frequency bandwidth). The system includes a staring sensor with N pixels (e.g., N>106) that searches for a sinusoidal frequency of unknown phase and frequency, perhaps constrained to a particular band by a priori information about the signal. Counters in the sensor pixels mix the detected signals with local oscillators to down-convert the signal of interest, e.g., to a baseband frequency. The counters store the down-converted signal for read out at a rate lower than the Nyquist rate of AM signal. The counts can be shifted among pixels synchronously with the optical line-of-sight for scanning operation.	Communication Devices- Optical & Photonic Communications	Optical Terminal Verification Testbed
Inductance-tuned electro-optic modulators	9,671,670	6/6/17	Mark A. Hollis, Reuel B. Swint, Dominic Siriani, Joseph P. Donnelly, Paul William Juodawlkis	The featured technology is an advanced electro-optic modulator. This device operates by translating the information enclosed in an electrical signal moving on a transmission line onto an optical carrier. The modulator uses the variations in the electrical signal's voltage as a way to modulate the refractive index or absorption inside an electro-optic material from which the optical carrier propagates. Its design attempts to match the microwave and optical waves in speed, ensuring optimal bandwidth and modulation efficiency. To achieve this balance, the modulator uses tuning of the microwave transmission line's inductance to match the velocity of microwaves with optical group velocity across bandwidths of 100 GHz or more. Unlike conventional modulators, which often have a microwave velocity higher than the optical group velocity, this technology manages to maintain a microwave impedance of 50Ω. Traditional efforts to reduce microwave velocity, such as tuning a microwave transmission line's capacitance, usually diminish the impedance below the 50Ω mark of most microwave components. However, the present technology differentiates itself by being able to balance both the impedance and velocity effectively.	Communication Devices- Optical & Photonic Communications	Optical Terminal Verification Testbed
Optoelectronic filter and method for signal suppression	9,971,226	5/15/18	Paul W. Juodawlkis, William Loh, Rajeev J Ram, Siva Yegnanarayanan	This invention is an optoelectronic filter designed to balance different RF signals. The filter comes equipped with a modulator circuit with first and second inputs. The first input receives two RF signals with different power levels and subsequently generates a modulated signal at the output. Crucially, the first RF signal in the modulated output is suppressed relative to the second, fine-tuning the balance between varying frequency signals. Additionally, the filter includes a light source connected to the second input of the modulator. The standout feature of this invention is the differential suppression of RF signals, enabling the filter to handle frequency signals of varying power more effectively. The inclusion of a modulator circuit that manages RF signals and a light source adds to its versatility. The ability to suppress stronger signals ensures a more balanced output signal, reducing the chances of one signal overpowering others — a differentiating factor in the crowded space of electronic filters.	Communication Devices- Optical & Photonic Communications	Optical Terminal Verification Testbed
Patterned non-reciprocal optical resonator	8,837,877	9/16/14	Lionel C. Kimerling, Caroline A. Ross, Lei Bi, Peng Jiang, Juejun Hu, Dong Hun Kim, Gerald F. Dionne	The invention described is an innovatively patterned nonreciprocal optical resonator structure. It consists of a resonator structure that receives an optical signal, a top cladding layer selectively deposited on the resonator, and a core part exposed by patterning the cladding layer. The most distinctive component is a magneto-optically active layer deposited upon the exposed core. This layer is characterized by a magneto-optical medium that is crucial for the functioning of the device. This technology is differentiated primarily due to its ability to generate nonreciprocal optical signals. While traditional optical resonators struggle with bidirectionality of signals, the selective layering technique of this invention facilitates desired optical nonreciprocity. The use of a magneto-optically active medium not only contributes to nonreciprocity but also expands the range of possible applications.	Communication Devices- Optical & Photonic Communications	Optical Terminal Verification Testbed
On-chip miniature optical isolator	8,749,871	6/10/14	Juan C. Montoya, Steven J. Spector, Reuel Swint, Caroline A. Ross	The discussed technology involves an optical structure designed to generate nonreciprocal loss using a magneto-optical layer integrated on a first substrate layer. External magnetic field application brings about nonreciprocity, leading to a resonantly enhanced nonreciprocal loss. The nature and placement of these layers allow for greater control and manipulation of light properties, significantly increasing loss nonreciprocity. What differentiates this technology is its ability to induce resonantly enhanced nonreciprocal loss through the application of an external magnetic field. Such a design essentially amplifies the nonreciprocity of the optical system. By capitalizing on the interaction between the magnetic field and the magneto-optical layer, this technology paves the way for highly controlled and efficient modulation of light properties, a notable advancement in the field of optical technology.	Communication Devices- Optical & Photonic Communications	Optical Terminal Verification Testbed
Very large mode slab-coupled optical waveguide laser and amplifier	8,451,874	5/28/13	Robin K. Huang, Joseph P. Donnelly	The very large mode (VLM) slab-coupled optical waveguide laser (SCOWL) includes a layered design with upper and lower waveguide regions and an active region nestled in between. These waveguide regions guide the laser mode. The lower guide region is found underneath the upper one, and the active region is set up to allow etching into the VLM SCOWL. The etching forms one or more ridge structures while leaving the active region untouched. The unique aspect of this technology is the inclusion of one or more mode control barrier layers. These layers are tactfully positioned between the upper and lower waveguide regions. Their significant function is controlling the fundamental mode profile and, importantly, preventing mode collapse. They serve as an obstacle for carrier leakage from the active region, making them crucial for effective VLM SCOWL operation.	Communication Devices- Optical & Photonic Communications	Optical Terminal Verification Testbed

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Patent title, as issued	Patent Number	Date issued	Inventor name(s)	Brief Description of Patent (Claims/Field of Use)	Technology area subfields	Facilities available that may support continued R&D
Methods and apparatus for photonic-enabled radio-frequency (RF) cancellation	10,812,118	10/20/20	Kenneth E. Kolodziej, Bradley PERRY, Siva Yegnanarayanan	In-band full-duplex (IBFD) wireless systems provide a groundbreaking approach to frequency spectrum utilization for future networking technologies. These systems require self-interference to be substantially mitigated, a task that becomes challenging as the bandwidth expands. A photonic-enabled RF canceller allows for interference reduction, currently limited to narrowband operation or distinct environments. This canceller provides advanced broadband interference cancellation using photonic components in a wideband vector modulator architecture with tunable time-delay taps. A working example of this technology is showcased with 20 canceller taps offering 25 and 20 dB of cancellation over 500-MHz and 1-GHz bandwidths respectively. This technology differs from others because of its capability to provide wide bandwidth operation and high tap counts. The introduction of a wideband vector modulator architecture ensures a significant reduction in interference, making it a potential game-changer for future wireless systems. The use of photonic components provides a reliable, repeatable, and sustainable interference reduction mechanism, specifically designed to adapt to the increasing bandwidth needs of future wireless networks.	Communication Devices- Optical & Photonic Communications	Optical Terminal Verification Testbed
Antenna beam steering through waveguide mode mixing	9,136,607	9/15/15	James P. Anderson	This technology is a unique method and an apparatus to electronically manipulate antenna beams. It accomplishes the beam steering by modifying the electric field laid out at the open end of one or multiple over-moded waveguides, made possible through precise controlled blending of many modes. This technique involves passing a signal through multiple modes in a waveguide, and the relative phase and amplitude of each mode are altered in relation to other modes to steer the beam. This technology sets itself apart as it provides fine adjustments to the steering angle and enables tight beam scanning, a characteristic that conventional methods can struggle to achieve. Furthermore, this new method reveals an innovative configuration, including a common waveguide for propagating several modes, two specific waveguides for propagating its first and second modes, and a splitter/combiner for coupling the first and second waveguides to the common waveguide. The controller efficiently adjusts the propagation characteristic relating different modes together in at least one path to steer the antenna beam.	Communication Devices- Optical & Photonic Communications	Optical Terminal Verification Testbed
Methods and apparatus for free-space undersea communications	10,491,309	11/26/19	Hemonth Rao, Andrew Fletcher, Scott Hamilton, Nicholas Hardy, Marvin Scheinbart	The multi-rate, burst-mode, photon-counting receiver, capable of data rates up to 10.416 Mb/s, is equipped for underwater communication. Its robust performance displays a maximum link loss of 97.1 dB, allowing it to communicate over distances up to 450 meters depending upon the light wavelength utilized. With soft-decision forward error correction, it affords multiple code rates for error-free performance. The burst-mode receiver architecture is specifically designed to endure unpredictable channel obstructions. The power of the receiver lies in its ability to adapt to ever-fluctuating conditions. It can detect the data rate on-the-fly and adapt to changes in signal and background light. Furthermore, it modifies its phase alignment and channel estimates every frame. It allows for rapid amendments necessitated by swift changes in water quality and motion between transmitter and receiver, setting it apart from conventional technologies.	Communication Devices- Optical & Photonic Communications	Optical Terminal Verification Testbed
Multi-spatial mode enabled PAT and AO terminal architecture for free-space optical communications	10,892,824	1/12/21	David J Geisler, Timothy M Yarnall	This technology involves a pointing, acquisition, and tracking (PAT) terminal used in free-space optical communication systems. Unlike conventional technology, which reduces signal-to-noise ratio and sensitivity by drawing energy for tracking purposes, this PAT terminal estimates the tilt angle without any such diversion. It employs a passive-mode converter, like a photonic lantern, mapping power in each spatial mode at the reception aperture to unique single-mode output. Photodetectors are then used to convert the received light into electrical signals. What sets this technology apart is its ability to ensure more efficient coupling of received light to a detector while maintaining the energy needed for communications. Conventional PAT systems diminish their overall performance by diverting energy toward tilt measurement in the focal plane. By recording the distribution of power across different spatial modes for PAT and converting it into tilt information, this methodology eliminates the need for energy diversion, resulting in robust communications with better signal quality.	Communication Devices- Optical & Photonic Communications	Optical Terminal Verification Testbed
Single-frequency fiber amplifier with distal cladding stripper	11,108,209	8/31/21	Steven J. Augst, Kelsey Yee, Franklin Jose	The fiber lasers are designed to operate at higher stimulated Brillouin scattering (SBS) power thresholds. The technique includes the use of high-absorption gain fibers, operation at low pump absorption levels, reduction of the length of unpumped gain fiber at the output, and omission of a delivery fiber and cladding light stripper at the output. Additionally, free-space dichroic mirrors are employed for separating signal light from unabsorbed pump light, and cascaded gain fibers with nonoverlapping Stokes shifts are used. What differentiates this technology from other fiber lasers is the complexity of the techniques used. The lasers have been designed with a high-absorption gain fiber and follow up with a smaller diameter to improve beam quality. This upgrade in the fiber lasers enables an upper limit to their power, given that SBS occurs only when the power exceeds a designated threshold. By augmenting SBS power thresholds, these fiber lasers can deliver superior maximum powers at kilohertz-class linewidths.	Communication Devices- Optical & Photonic Communications	Optical Terminal Verification Testbed
Optical receiver configurable to accommodate a variety of modulation formats	10,009,115	6/26/18	David O. Caplan	The invention is a sophisticated optical signal demodulator. It takes M input optical signals, such as wideband M-ary orthogonal, and by utilizing an optical processor transforms them into 2 log2(M) intermediary optical signals. The ingenious comparison module in the invention then determines the logical representation of the initial input data on the basis of the optical power of these intermediary signals. The demodulator exhibits compatibility with a range of modulation formats including M-FSK, M-PPM, M-PolSK, and hybrid M-ary orthogonal. What sets this invention apart is its capability to function in both free-space and fiber-optic environments, ideally suited for applications requiring smaller hardware dimensions and minimal power requirements. Furthermore, embodiment examples of this technology offer both reduced electronic bandwidth requirements and enhanced receiver sensitivity. The demodulator's inherent compatibility with different modulation formats and its scalability make it ideal for diverse optical communication applications.	Communication Devices- Optical & Photonic Communications	Optical Terminal Verification Testbed
Filter-based DPSK communications system	8,886,049	11/11/14	David O. Caplan, Mark L. Stevens	A filter-based method to demodulate differentially encoded phase shift keyed (DPSK) optical signals is applicable to both binary-DPSK (DBDPSK) and quadrature DPSK (DQPSK) signals. It combines filtering and differential phase comparison to enhance the receiver's sensitivity. Significantly, this innovative approach overrides the need for delay-line interferometer-based demodulation, thus reducing the complexity and cost of DPSK receivers. The uniqueness of this technology lies in its ability to reduce the DPSK receiver's size, weight, and power, while improving stability. Despite these reductions, the method maintains the capability to achieve exceptional communication performance. Therefore, it sets itself apart by ensuring optimal receiver sensitivity, which significantly contributes to improving the efficiency and effectiveness of optical communication systems.	Communication Devices- Optical & Photonic Communications	Optical Terminal Verification Testbed
Short pulse wavelength tuning via timed soliton-dispersive wave interaction	10,770,859	9/8/20	Jason E. Langseth, Darren A. Rand	This innovative laser system capitalizes on the interaction between a soliton and a dispersive pulse in an optical fiber in order to generate adjustable output wavelengths. It leverages an effect known as cross-phase modulation, wherein one pulse manipulates the refractive index experienced by the other, resulting in wavelength shifts in each pulse proportionate to the time delay between them. This method enables the production of pulses with tunable output wavelengths over large distances, such as hundreds of nm, at rates reaching up to megahertz or gigahertz. What sets this technology apart is its exclusion of mechanical components, ensuring unparalleled reliability. The entirety of the laser's optical path is composed of optical fiber, allowing it to function with high efficiency and low power consumption, size, and weight. The variable wavelength functionality, coupled with its compact and efficient design, makes this laser system a distinct change from traditional laser systems.	Communication Devices- Optical & Photonic Communications	Optical Terminal Verification Testbed
Apparatus, systems, and methods for nonblocking optical switching	11,112,564	9/7/21	Gregory R. Steinbrecher, Dirk Robert Englund	This technology is a method for nonblocking optical switching. This sophisticated method drives a first optical beam from one input to an output via a specific path in an optical switching fabric. This path passes through a phase shifter sandwiched between a set of cascaded Mach-Zehnder interferometers. Additionally, the method accommodates a second optical beam for a different path intersecting with the first in the optical switching fabric. The unique aspect of this technology is that it can relocate the first optical beam from its initial path to an alternate one, linking the initial input and output, but without crossing the second light path. This shift is coupled with a phase shift of the first optical beam, administered by the phase shifter, as the beam moves to its new path. This prevention of interference between the first and second optical beams differentiates this technology and boosts its efficiency.	Communication Devices- Optical & Photonic Communications	Optical Terminal Verification Testbed
Apparatus and methods for reconfigurable optical receivers	10,075,245	9/11/18	David O. Caplan, Michael R. Watts, Zhan Su	This technology centers around an optical receiver composed of a sequence of optical filtering elements. These filters select spectral components from incoming optical signals at wavelengths aligned to their respective filter passbands. This filtering mechanism is designed to subsequently combine selected spectral components into several pairs of intermediary signals, where the number of pairs equals log2(M). From these pairs, a digital representation of the original signal is generated. The ingenuity of this optical receiver lies in its configuring of the filtering elements to accomplish demultiplexing and demodulation concurrently, thereby enhancing functionality while lessening unnecessary losses. The receiver's versatility is further displayed in its ability to be retuned to accommodate a varying range of combinations of wavelengths and modulation formats including wavelength-division multiplexing (WDM), on-off keying (OOK), M-ary orthogonal formats like frequency shift keying (FSK) and pulse position modulation (PPM), differential phase shift keying, and other hybrid combinations. The system achieves noteworthy rate and format flexibility, and WDM scalability.	Communication Devices- Optical & Photonic Communications	Optical Terminal Verification Testbed
Defensive routing and related techniques	11,347,902	5/31/22	Kevin B. Bush, Matthew D. Hicks, Timothy D. Trippel	Defensive routing involves creating a secure, preventive layout for security-critical wires, inhibiting fabrication time attacks in an integrated circuit (IC). This refined method includes identifying security-critical wires in an IC design, finding any unblocked surfaces, and protecting those surfaces with a guard wire. The guard wire, which could either be natural or synthetic, is positioned strategically around the surfaces of security-critical wires as a critical defensive shield. The technology differentiates itself by taking a proactive, routing-centric approach to securing against IC wire attacks during fabrication. It reduces the vulnerabilities of the design, especially during fabrication, by securing the surfaces of identified crucial security wires with a guard wire. Its dual consideration of natural and synthetic guard wires further underscores its flexibility and robustness in defense.	Communication Devices- Networking & Security Protocols	Optical Terminal Verification Testbed
Optimized transport layer security	10,341,302	7/2/19	Roger I. Khazan, Daniil M. Utin	The invention puts forward a method for initiating a secure communication session between client devices and server computers according to a specific communication protocol. This method involves passing communication through a proxy device along the communication path. Crucially, session initiation information gets transferred between the client devices and server computers via this proxy. The secure communication sessions, each quantified for exclusive access from a particular client device and server computer using the shared session initiation information, facilitate the transmission of encrypted content. The compelling feature that differentiates this technology is the proxy's inability to access the content of the communication, reinforcing the security of the transmission. Furthermore, the proxy alters some information between a client device and a server computer, ensuring that communication from and to the server complies with the communication protocol. This approach offers robust, reliable secure communications in the face of escalating cybersecurity threats.	Communication Devices- Networking & Security Protocols	Optical Terminal Verification Testbed
Packet header randomization	9,712,501	7/18/17	Hamed Okhravi, Richard W. Skowyra, Kevin Bauer, William W. Streilein	This system and method involve the randomization of packet headers used in network routing. The technology uses a controller to provide random values, also known as nonces, that replaces the traditional source and destination addresses in packet headers. The controller also supplies the network's switches and routers with routing rules to ensure proper packet routing despite the absence of source and destination addresses. Network devices compatible with software-defined networking (SDN) might be utilized in some iterations. The frequency of usage of a particular nonce could be variable, with the possibility of some nonces used for a single packet header. The introduction of nonce replaces the usual addresses, enabling packets to navigate a network with nonces instead of the actual source and destination addresses. By periodically changing the nonces, the technique makes it exceedingly challenging to discern traffic patterns. The proposed technology introduces an unpredictability element into network routing, thereby enhancing anonymity and reducing the chance of unauthorized data access.	Communication Devices- Networking & Security Protocols	Optical Terminal Verification Testbed
Architecture for content and host-centric information dissemination in delay-tolerant MANETs	9,119,226	8/25/15	Praveen Sharma, Jason Biddle, Aaron Daubman, Evan Fiore, Timothy Gallagher), eremy Mineweaser, Santiago Paredes, Daniel Souza, Heather Zwahlen, Maximillian Merfield, Larry Robinson	This technology focuses on an architecture designed for mobile ad hoc networks (MANETs) made up of smartphones. It allows for both content-centric and host-centric communications, which are delay tolerant. Cross-network communications and Internet sharing are key features, permitting sharing if one of the smartphones has internet access. Two distinct routing mechanisms are included, one for content-centric communication and another for host-centric communications. It employs variations of the optimized link state routing (OLSR) protocol and a modified version of PRoPHET for routing content-centric communications. What differentiates the technology is its use of various alternatives of store and forward for host-centric communications, such as binary spray and wait, designed to provide preferred routing paths. The communication between mobile devices capitalizes on wireless communication, with a focus on the IEEE802.11 standard. This specialized architecture is built with an emphasis on smartly managing communication pathways and overcoming the issue of delays in MANETs.	Communication Devices- Networking & Security Protocols	Optical Terminal Verification Testbed

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Patent title, as issued	Patent Number	Date issued	Inventor name(s)	Brief Description of Patent (Claims/Field of Use)	Technology area subfields	Facilities available that may support continued R&D
Methods and systems for signal interference cancellation	11,611,423	3/21/23	Kenneth E. Kolodziej	This system is designed to tackle signal interference (SI) in concurrent signal transmission and reception within a single frequency band. It possesses a transceiver that sends and receives signals simultaneously, indirectly contributing to signal interference between transmitted and received signals. To deal with this interference, an SI canceller is integrated into the system, which uses an array of cancellation coefficients to generate a mitigating signal. What sets this system apart is its capability to iteratively fine-tune these cancellation coefficients by leveraging a step factor. This step factor is determined by a cancellation error gradient and one or more factors such as tunable coefficient step aggressiveness and a time-based forgetting factor. The system prompts the SI canceller to cancel the interference by utilizing these finely-tuned cancellation coefficients, conferring superior control and precision to signal interference mitigation.	Communication Devices- Beamforming, Signal Combining & Adaptive Systems	Optical Terminal Verification Testbed
Planar Luneburg lens system for two-dimensional optical beam steering	11,579,363	2/14/23	Josue Lopez, Samuel Kim, Jamison Sloan, Boris Kharas, Jeffrey Scott HERD, Marin Soljacic, Cheryl Marie Sorace-Agaskar, Suraj Deepak Bramhavar, Steven Glenn Johnson, George Barbastathis	The integrated optical beam steering device features a unique composition of a planar Luneburg lens and a curved grating coupler. The lens, likely composed of subwavelength features, collimates beams from different inputs in various directions within the lens plane. The grating coupler then diffracts these collimated beams out of the lens plane. Beam direction can be controlled within and outside the plane through lens illumination and beam wavelength variation. What sets this technology apart is its capability of operating over an extremely wide field of view — up to 180° — without any aberrations off boresight. This approach offers uniform beam quality in all directions, a feature not seen in aplanatic lenses. The circular symmetry of the planar Luneburg lens allows for this design. Additionally, this lens is robust to misalignment and fabrication imperfections and can be fabricated using standard CMOS processes.	Communication Devices- Beamforming, Signal Combining & Adaptive Systems	Optical Terminal Verification Testbed
Distributed airborne beamforming system	10,312,984	6/4/19	Navid Yazdani, David W. Browne, Keith William Forsythe	The system is a distributed beamforming communication system characterized by the utilization of independent aerial nodes or platforms. These create an antenna array capable of functioning without strict control of their position, efficient inter-node communication, or a coordinated transmission among the nodes themselves. Notably, each node operates as an independent entity within the array. This unique feature differentiates this beamforming system from conventional methods. Most existing beamforming arrays require controlled positioning of each node, inter-node communication, and coordinated transmission to successfully function. This new technology disrupts this notion by eliminating the need for inter-node coordination, hence saving overhead and ensuring flexibility. It provides scalability allowing it to handle a larger number of users and overcoming the limitations posed by the traditional methods.	Communication Devices- Beamforming, Signal Combining & Adaptive Systems	Optical Terminal Verification Testbed
Methods and apparatus for acoustic laser communications	11,082,127	8/3/21	Charles Wynn, Yaron Rachlin, Ryan Sullenberger, Sumanth Kaushik	The ability to communicate with a specific subject at a prescribed location who lacks any communications equipment opens up many intriguing possibilities. Communications across noisy rooms, hail and warn applications, and localized communications directed at only the intended recipient are a few possibilities. We disclose and show localized acoustic communications, which we call photoacoustic communications, with a listener at long standoff distances using a modulated laser transmitted toward the receiver's ear. The optically encoded information is converted into acoustic messages via the photoacoustic effect. The photoacoustic conversion of the optical information into an audible signal occurs via the absorption of the light by ambient water vapor in the near area of the receiver's ear followed by airborne acoustic transmission to the ear. The recipient requires no external communications equipment to receive audible messages.	Communication Devices- Hybrid / Novel Communications	
Two-Phase Helium Convection Loop for Cryogenic Cooling	17/721,639	pending	John Cummings, George Haldeman, Lawrence Narkewich , Sergey K. Tolpygo, John Ingwersen	This technology provides a comprehensive system for wafer-level testing of superconducting and low-temperature circuitry, operating below 5 Kelvin. It features a two-chamber vacuum architecture with actively and passively cooled heat shields, and an inner chamber constructed from high-purity, high-thermal-conductivity metals. A novel two-part wafer-holding structure includes a removable wafer carrier, designed with materials matching the wafer's thermal expansion, and a fixed chuck for precise force application and alignment. A key component is a passive helium convection loop, utilizing an evaporator integrated into the chuck and a condenser on the cryocooler, connected by flexible bellows, to ensure efficient heat transfer. The system also incorporates a load lock for wafer insertion without breaking vacuum and a precise mechanical positioning stage.	Quantum	Microelectronics Laboratory
Multiloop interferometers for quantum information processing	10,283,693	5/7/19	Andrew J. Kerman	This technology employs structures and techniques based on superconducting Josephson-junction circuits to facilitate the direct engineering of multiple quantum bit (multi-qubit) interactions in a nonperturbative manner. The system incorporated includes a multispin coupler, composed of several loops, each harboring a pair of Josephson junctions. This coupler is inductively linked with a variety of qubits. This implementation utilizes the distinct properties of quantum physics to carry out computing operations, optimizing information processing tasks. Unlike traditional quantum computing approaches, this technology can establish multiple qubit interactions directly and in a nonperturbative fashion. The unique combination of Josephson junctions and a multispin coupler allows for precise control over qubit interactions, thereby enhancing the computational capabilities and reliability of the system. This design overcomes key limitations of the previous systems, ensuring improved scalability and an elevated level of control.	Quantum	Microelectronics Laboratory
Josephson phase-slip qubits	10,735,003	8/4/20	Andrew J. Kerman	This technological advancement describes a qubit composed of a superconducting loop divided by several magnetic flux tunneling elements. These tunneling elements include DC SQUIDs (direct current superconducting quantum interference devices) that create superconducting islands spaced between them. By magnetically tuning each element, a significant tunneling amplitude is achieved, forming an effective transverse magnetic moment. Furthermore, the electrical polarization charge of each island is fine-tuned to invoke destructive interference, thus nullifying the transverse field. This qubit model is differentiated by its potential to resume tunneling with substantial amplitude when the charge is biased away from its initial settings. This property allows for maximum control in quantum computations. A third tunneling path, such as a Josephson junction, can be introduced to create two independent islands. This configuration facilitates the fine-tuning and independent management of two distinct (X and Y) transverse fields, which poses a significant advantage for quantum computing applications.	Quantum	Microelectronics Laboratory
Utilization Of Halides To Improve Diamond Properties	18/796,054	pending	Dane William De Quilettes, Eden C. Price, Justin Lee Mallek, Jennifer May SCHLOSS, Danielle A. Braje	Described here are diamond materials that incorporate defect centers formed by substituting carbon atoms with nitrogen or silicon, paired with vacancies that may be neutral or negatively charged. Halide atoms are integrated into the diamond lattice to enhance defect formation. The process involves precision techniques such as chemical vapor deposition and plasma enhanced deposition, careful control of implantation energies and annealing conditions, and the use of dopant gases. These controlled conditions yield diamond layers with tailored NV and Si vacancy centers suitable for use in quantum computing, sensing, and advanced optical applications. What differentiates this approach is the strategic use of halide atoms—particularly chlorine—to significantly boost the formation of negatively charged defects. This multidonor doping strategy reduces the activation energy for NV center formation, resulting in an approximate eightfold increase compared to conventional nitrogen-only doping. Moreover, the refined methods of layer growth and post-treatment processing lead to improved charge stability, enhanced coherence times, and overall superior crystalline quality, setting this technology apart in the realm of diamond material engineering for quantum and optical applications.	Quantum	Microelectronics Laboratory
Quantum Mixer to Sense Arbitrary-Frequency Fields	18/193,730	pending	Guoqing Wang, Yixiang LUI, Jennifer Schloss, Scott Alsid, Danielle A. Braje, Paola Cappellaro	Quantum sensors achieve high sensitivity and spatial resolution but are typically limited to detecting signal fields within specific frequency ranges. This technology utilizes the sensor qubit as a frequency mixer, enabling the detection of arbitrary-frequency signals by leveraging nonlinear effects in periodically driven (Floquet) quantum systems. By combining the signal with an applied AC bias field, a frequency-mixed field is generated, which can be detected using established sensing techniques such as Rabi oscillations and CPMG sequences. The system comprises components like nitrogen-vacancy centers in diamond, an AC bias field generator, signal detection antenna, state measurement detector, and signal processing unit. This approach facilitates vector magnetometry across a broad frequency spectrum, as demonstrated by the ability to sense a 150 MHz signal field using NV centers.	Quantum	Microelectronics Laboratory
Optimization of quantum-active defects and spins in chemical systems using machine learning	WO2024232966A2	pending	Dane William DEQUILETTES, Eden C. PRICE, Swaroop VATTAM, Danielle BRAJE, Justin Lee MALLEK, Jennifer May SCHLOSS, Linh M. PHAM	The technology employs machine learning models to enhance the manufacturing of quantum materials by optimizing fabrication parameters based on the characterization of their quantum properties. The process begins with creating an initial quantum material sample and evaluating its properties, such as dephasing time, contrast, and NV density in diamond systems with NV centers. Data from these characterizations are used to train regression models using advanced machine learning techniques like gradient boost, random forest, and stacking regression. These models establish correlations between fabrication parameters—including seed miscut angles, growth time, and irradiation dose—and a figure of merit that measures material quality. Using the trained models, improved fabrication parameters are identified and applied to produce subsequent samples with enhanced quantum properties through an iterative manufacturing process.	Quantum	Microelectronics Laboratory
Qubit circuits with deep, in-substrate components	11,699,091	7/11/23	Wayne Woods, Danna Rosenberg, Cyrus Hirjibehedin, Donna-Ruth Yost, Justin Mallek, Andrew Kerman, Mollie Schwartz, Jonilyn Yoder, William Oliver, Thomas Hazard	The described technology relates to quantum circuitry (qubit circuits), which contains components engineered deep in a substrate material. Notably, these components could be superconducting current loops, inductive, or capacitive components. Manufactured employing existing integrated-circuit technologies, these qubit circuits aim to economize the footprint within the substrate, therefore making the circuit more compact. What sets this technology apart is the improvement it offers in both coupling efficiency to and from the qubit and the reduction of losses in the qubit circuit. Forming the qubit circuit's components deep within the substrate not only enables a more streamlined footprint but also enhances performance and efficiency, promising an overall optimized quantum computing solution.	Quantum	Microelectronics Laboratory
Physical-layer quantum error suppression for superconducting qubits in quantum computation and optimization	10,942,804	3/9/21	Andrew J. Kerman	The technology in question is a device that combines physical qubits into logical ones through the use of a passive, quantum error-suppressing code. It also intertwines these qubits into a computational or annealing fabric by using an active, quantum error-correcting code. The device manages to counter environmental noise, such as thermal fluctuations, by employing enough physical qubits in each logical one. Interaction between individual logical qubits is facilitated via multiple physical qubits interactions; for this, intermediary circuitry that can couple four or more spins is used. What sets this technology apart is its ability to tackle the pesky problem of ambient noise that often interferes with quantum computations. Unlike other approaches, the active and passive codes used do not increase the circuit's complexity or reduce gate operations speed. Integrating an ancilla qubit to the intermediary circuitry facilitates the formation of a logical qubit with passive error suppression, allowing arbitrary computations to be performed using a fabric of such circuitry.	Quantum	Microelectronics Laboratory
Quantum measurement emulation error mitigation protocol for quantum computing	11,715,026	8/1/23	William Oliver, Seth Lloyd, Danna Rosenberg, Michael O'Keeffe, Amy Greene, Morten Kjærgaard, Mollie Schwartz, Gabriel Samach, Iman Marvian Mashhad	This technology offers systems and methods for performing open-loop quantum error mitigation by using quantum measurement emulations. Unlike traditional quantum error-mitigation methods, they do not necessitate state readouts or state tomography, thus leading to lower hardware requirements. The technology instead employs an error-mitigation apparatus that, at specified moments during a quantum computational process, stochastically applies a quantum gate to a qubit or a group of qubits. The standout characteristic of this technology is the stochastic application of a quantum gate, which projects the quantum state of the influenced qubits onto an axis. This process effectively reduces the trace distance between the current quantum state and the desired quantum state. By reducing this distance, the technology increases the overall speed of quantum computations, amounting to a more efficient and performance-optimized quantum computing methodology.	Quantum	Microelectronics Laboratory
System and Technique for Loading Classical Data Into A Quantum Computer	11,113,621	9/7/21	John CORTESE, Timothy BRAJE	This technology deals with quantum circuits and methods designed to load N = 2n classical bits into an entangled quantum output state, only utilizing a gate depth of order O(n). This loading process involves dividing the 2n input bits into data words and subsequently entangling them by relying on ancilla qubits. Generated circuit output comprises a single data word, coupled with one or more index qubits selected from the ancilla to differentiate between input data words. What differentiates these quantum circuits and methods is their efficiency and capacity. The software manufactures entanglement of the data words in a singular time slice, arguably with a gate depth of 1. Also, the number of sequential gates required to produce the appropriate pre-entanglement quantum state in the ancilla, and to disentangle the non-output ancilla, adheres to the desired order O(n). Additionally, these quantum circuits can also disentangle qubits used to hold non-output data words during processing, demonstrating the adaptability of the innovation.	Quantum	Microelectronics Laboratory

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Patent title, as issued	Patent Number	Date issued	Inventor name(s)	Brief Description of Patent (Claims/Field of Use)	Technology area subfields	Facilities available that may support continued R&D
Stationary magic angle spinning enhanced solid state spin sensor	10,705,163	7/7/20	John F. Barry, Danielle A. Braje, Erik R. Eisenach, Christopher Michael McNally, Michael F. O'Keeffe, Linh M. Pham	Introduced is a solid-state spin sensor featuring enhanced sensitivity achieved by extending the T2* dephasing time of the color center defects. This approach minimizes the dipolar coupling among paramagnetic defects present within the sensor. The mitigation of dipolar coupling is realized by deploying a magic-angle-spinning magnetic field directed at the color center defects, generated through phase-shifted sinusoidal waveforms from a well-matched current source to the magnetic field generator, such as Helmholtz coils. The differentiating factor of this technology lies in its application of a magic-angle-spinning magnetic field on color center defects to reduce their dephasing, thus enhancing the sensor's sensitivity. The field frequency, contingent on the precession period of the color center defects, further improves measurement sensitivity by reducing the dephasing of these defects. This advancement offers a substantial improvement compared to existing solid-state spin sensors, marking a significant breakthrough in the field.	Quantum	Microelectronics Laboratory
Paramagnetic tree coupling of spin qubits	10,719,775	7/21/20	Andrew J. Kerman	This innovative technology is a structure and methodology for facilitating highly connected qubit interactions. The method employs a distinct "paramagnetic tree coupling" scheme. The system comprises multiple qubits, each connected to every other via a paramagnetic medium, which includes a series of inductive couplers. This arrangement allows for enhanced connections between the qubits, which are critical components in quantum computing. The unique aspect of this invention lies in its use of paramagnetic media to link the multitude of qubits in a quantum computing system. This technology is contrasted against standard methods that usually use individual cables. The paramagnetic tree coupling fosters highly connected, efficient qubit interactions. The inductive couplers integrated into the paramagnetic medium amplify the interconnectedness and interaction capabilities, resulting in higher efficiency in quantum computing tasks.	Quantum	Microelectronics Laboratory
Four spin couplers for quantum information processing	10,396,801	8/27/19	Andrew J. Kerman	The technology, centered around superconducting Josephson-junction-based circuits, aims to develop physical multiqubit, or "many-qubit," interactions in a nonperturbative manner. The system features a multispin coupler that includes numerous loops — each housing a pair of Josephson junctions — and multiple qubits that are each inductively linked with the multispin coupler. This technology is a significant advancement in the quantum computing landscape because it allows direct engineering of multiqubit interactions. The non-perturbative approach allows manipulating more universal classes of many-body interactions, which aren't possible with standard techniques. The Josephson junction-based circuits are an important component because of their superconductive properties, marking a significant threshold in the technological development of quantum computing systems.	Quantum	Microelectronics Laboratory
All Electrical Fully Connected Coupled Oscillator Ising Machine	11,552,595	1/10/23	Jeffrey Chou, Suraj Deepak Bramhavar, Christopher Roberts, Christopher A. D. Roeser, Siddhartha Ghosh	Networks of superharmonic injection-locked (SHIL) electronic oscillators can emulate Ising machines to solve complex computational issues. The oscillators, either simulated or physically implemented (e.g., with LC oscillators), are connected to one another via links whose connection strengths align with the problem to be solved. The phases of these oscillators are measurable relative to one reference signal or multiple signals emitted from reference oscillators, which do not receive any input from other oscillators. The technology stands out in its application as Viterbi decoders and Boolean logic gates. Viterbi decoders constructed with sparsely connected SHIL oscillator networks are not prone to the digital computation problem of an information bottleneck between logic computational blocks and memory. Furthermore, these networks can be programmed to function as Boolean logic gates operating bidirectionally, facilitating factoring numbers with multipliers.	Artificial Intelligence	
Methods and apparatus for analog canceler tuning using neural networks	11,626,966	4/11/23	Kenneth E. Kolodziej, Aidan U. Cookson, Bradley Thomas Perry	A network device includes a transceiver configured to concurrently transmit signals and receive signals within a single frequency band resulting in radio-frequency signal interference. The device includes an analog canceler configured to mitigate the signal interference. The device includes a neural network that receives data that describes characteristics of the signal interference and provides coefficients for the analog canceler as outputs. The neural network-generated coefficients are applied to the analog canceler which uses them to cancel the signal interference.	Artificial Intelligence	
Wafer-scale satellite with integrated propulsion and attitude control	11,444,027	9/13/22	Mordechai Rothschild, Sumanth Kaushik, Melissa A. Smith, Livia Racz, Dennis Burianek	The disclosed technology details a wafer-scale satellite bus constructed of a stacked array of functional diced circuits. The circuits are first produced according to a universal wafer design that includes electrical and power interconnects. Each of these wafers is then further processed using subsystem-specific techniques to deliver a range of functions like ground-based communications, propulsion control, fuel tanks, thrusters, and power generation. These different circuits are assembled into a single stack by using techniques such as wafer bonding. Surface components are mounted, and the circuitry is diced to create the final satellite. What sets this technology apart is its ability to incorporate mission-specific functions at any stage of assembly. These functions may be added by surface mounting onto the bus or through on-wafer circuitry or instrument packages designed to perform these functions. This method allows significant flexibility in implementation and minimizes the need for extensive modifications when tailoring the satellite bus for specific applications.	Space	
Inflatable reflector antenna and related methods	10,916,859	2/9/21	Alan J. Fenn, Jesse Mills, Frank Robey, James W. Finnell, JR., Bakari Hassan, Sean Crowley	The inflatable antenna can be deployed in space and other suitable environments and is primed to enhance RF performance and mechanical stability. Unique manufacturing and deployment techniques allow the inflatable antenna to form a Gregorian dual-reflector confocal parabolic antenna system when inflated. The technology encompasses various antenna mechanisms, structures, and innovative manufacturing and deployment methods that enhance the accuracy and precision of RF reflective surfaces of the primary and secondary reflectors, confocal alignment, and mechanical stability, broadening the spectrum of RF operation. The inflatable antenna technology stands out from existing alternatives in several ways. Aside from enhanced RF performance and mechanical stability, it offers a simplified manufacturing and deployment process. Its unique configuration also allows for an elevated level of precision and accuracy in RF reflective surfaces and confocal alignment. Consequently, the inflatable antenna not only enhances the range of RF operation but also does so with less complexity and more precision than current options.	Space	
Incoherently combining lasers	11,515,682	4/14/20	Christopher Hwang, Jason E. Langseth, Kelsey Yee, John Kim, Yin Wan Tam	The invention presents an innovative technique for incoherently combining light from different lasers while ensuring high brightness. The technique uses novel fiber-bundling instead of a traditional approach that packs adjacent fibers tightly. Fibers from different lasers are astutely bundled with their tips tapered to match a multimode output fiber. Additionally, a unique approach to augment brightness is also employed by reducing the outer diameters of the signal fiber claddings, allowing for closer bundling of signal fibers and coupling more signal fiber cores to a multimode output fiber. This unique approach of reducing the outer diameter of the pump fiber cladding or etching away corresponding portions of the signal fiber cladding sets this technology apart. This arrangement allows more pump light into the signal fiber cladding to significantly increase brightness. The entire process ameliorates the combinational challenges of conventional methods, establishing a novel approach to laser beam combining.	Directed Energy	
Methods, systems, and apparatus for coherent beam combining	9,134,538	9/15/15	Steven J. Augst, Juan Camilo Montoya, Tso Yee Fan, Antonio Sanchez-Rubio	This innovation involves coherent beam combining of multiple semiconductor laser gain elements to achieve significantly high output power in a diffraction-limited beam. The system is characterized by an active beam-combining system that brings together the optical beams emitted by the laser gain elements and consolidates them in an external resonant cavity setup. This configuration consists of a beam combiner that forms a singular coherent output beam from the multiple laser gain elements and a photodetector that monitors this power. The phase of each optical beam from the laser gain elements is regulated via a processor that uses the photodetector output. What makes this technology stand out is its potential for scalability. The processor makes real-time adjustments based on photodetector readings, using a stochastic parallel gradient descent (SPGD) algorithm for active phase control, and optimizes the power of the coherent output beam. Additionally, the technology enables a combining efficiency of about 81%, achieving an upper limit of 90% or more, showing a clear superiority over passive-phasing systems that are limited by scalability constraints.	Directed Energy	