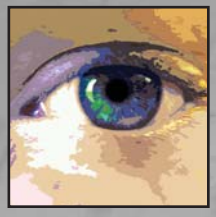
Missile Defense Agency Sensors:

Making the Unknown Known



Thanks to all the companies for their participation in this Missile Defense Agency Sensors report. We appreciate the time and effort it took to compile and share their stories, details, and graphics.

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Missile Defense Agency Mission Statement

"The Missile Defense Agency's mission is to develop, test, and prepare for deployment of a missile defense system. Using complementary interceptors, land-, sea-, air-, and space-based sensors, and battle management command and control systems, the planned missile defense system will be able to engage all classes and ranges of ballistic missile threats. Our programmatic strategy is to develop, rigorously test, and continuously evaluate production, deployment, and operational alternatives for the ballistic missile defense system. Missile defense systems being developed and tested by MDA are primarily based on hit-to-kill technology. It has been described as hitting a bullet with a bullet—a capability that has been successfully demonstrated in test after test."

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Introduction

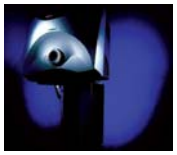
Most people have the use of five senses—hearing, taste, touch, sight, and smell. However, human senses are limited by biology; people cannot see in the infrared and have limited frequency discrimination. The Missile Defense Agency has funded land-, sea-, air-, and space-based sensor technology to support the ballistic missile defense system and perform the duties that go beyond human capability. These sensors support all three segments of defense in the system: boost, mid-course, and terminal. This report features 12 MDA-funded sensor technologies that have such capabilities as identifying and locating infrared sources, providing guidance to interceptors, discriminating decoys, creating 3-D images of far-off objects, and detecting multiple spectral bands simultaneously. The report highlights commercial applications for these sensor technologies as well. The same technology that discriminates between actual missiles and decoys can be used in facial recognition technology on the commercial market. The 3-D imaging system that can detect missiles hundreds of kilometers away can be applied to atmospheric and underwater imaging systems. Sensor technologies have multiple uses in various industries. They can provide the eyes and ears for defense and commercial technology.

Avalanche photodiodes

Advanced Photonix, Inc.

AVALANCHE PHOTODIODES OFFER A VERY UNIFORM ACTIVE AREA FOR HIGH-RESOLUTION IMAGES

Two APDs are used in Optos' Panoramic 200, which creates a single, high-resolution, ultra-widefield color digital image of the retina without using eye drops for pupil dilation.



Introduction

Advanced Photonix, Inc. (API; Camarillo, CA), is currently selling 5-mm, blue-enhanced avalanche photodiodes (APD) to Optos plc for a new, non-invasive retinal-scanning device. In the late 1980s and early 1990s, the BMDO, now MDA, SBIR program funded API to develop APDs as a replacement for photomultiplier tubes in LADAR receivers and missile seekers. API found a place for APDs in the commercial market. The uniformity of the active area of the APDs enables the production of high-resolution images that are 2,000 x 2,000 pixels.

API partnered with Optos to develop a critical part of the Panoramic 200™ Non-mydriatic, ultrawidefield Scanning Laser Ophthalmoscope, which uses two APDs. The output from the Panoramic 200 is known as the Optomap Retinal Exam: This is a single, high-resolution, ultra-widefield color digital image of the retina completed without using eye drops to produce pupil dilation. The Panoramic 200 allows visualization of up to 200 degrees inside the retina, a field of view significantly larger than has been available using traditional eye examination methods and equipment. This widefield view assists eye doctors in identifying early damage caused by a wide range of conditions from deterioration due to aging, sports injuries such as retinal detachment, and eye disease caused by diabetes complications. Obtaining the Optomap Retinal image is fast—the image capture takes less than one second, making this a convenient, quick and comfortable procedure for patients.

The Tool

API's APDs are full-field detectors with a very uniform active area, which enables the production of high-resolution images. The resolution of APDs is only limited by the size of the spot being scanned and the software used to grab the image. APDs combine the benefits of PIN photodiodes and photomultiplier tubes (PMTs). Unlike PMTs, APDs are also very rugged devices. To be incorporated into devices such as the Panoramic 200, a company needs to design for APDs from the very beginning. The Panoramic 200 uses lasers to scan across the active area of the APD; the laser reflects off the retina and bounces back into the active area to create a high-resolution image.

Its Status

API manufactures and distributes APDs for a variety of applications beyond retinal scanning, including radiation monitoring research and hard disk manufacturing. Optos' Panoramic 200 is API's most commercially successful application to date. Optos has offices in Europe and the United States. The Panoramic 200 was officially launched in the United States in 2000 and in Europe in 2001.

API is the industry leader in developing custom and standard silicon photodetectors and optoelectronic assemblies for a variety of markets and applications. It was founded in 1987 as a spinoff of Xsirius Scientific and is now a publicly traded company. The company was formed to commercialize APD research.

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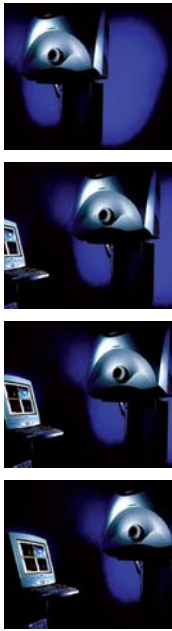

Advanced discrimination LADAR system

Advanced Scientific Concepts, Inc.

LADAR SYSTEM CAPTURES 3-D IMAGES IN ONE-THIRTIETH OF A SECOND

The ADLR system can be applied to atmospheric and underwater imaging systems.

Introduction

Advanced Scientific Concepts, Inc. (ASC; Santa Barbara, CA), is developing an advanced discrimination LADAR (ADLR) system that, using a laser pulse, can create a 3-D image in near real time. MDA funded the company to develop a 3-D LADAR system for target discrimination and seeker applications. LADAR systems are usually equipped with a scanner method—light has to scan over the target to form an image. However, the ADLR technology uses a flash system—one laser pulse captures the entire target in a 3-D image in one-thirtieth of a second. The ADLR system, including the sensor and all drive and output electronics, is a two-inch cube that can capture high-resolution images of objects that are hundreds of kilometers away. The critical technology, the readout integrated circuit (ROIC), is incorporated into an image tube developed by

Intevac, Inc., a partner of ASC. The image tube substantially amplifies the laser signal above sensor noise, allowing the detection of individual photons and decreasing the laser power requirements.

The Tool

The ADLR system is based on integrated circuits and image tube technology. A time-slicing technology is incorporated in each pixel of the two-dimensional ROIC array. When a laser pulse returns from one or more objects, a high-range-resolution 3-D image is produced from the captured data. The ADLR system creates an image that can be seen and measured in three dimensions. The technology provides a high-resolution, 3-D

image of even closely spaced target shapes. Data is multiplexed off the ADLR sensor between laser pulses so the receiver is not limited by real-time, multiple-independent-channel processing. The ADLR system is also compatible with a 12-bit digitizer, which creates a higher resolution image.

Its Status

The ADLR system will be available for use in 2004. It will cost about $20,000 with the image tube, but without the laser. Being a two-inch cube, the ADLR system can be incorporated into a missile kill vehicle for target identification applications in missile defense. The ADLR system can be applied commercially to atmospheric and underwater imaging systems. ASC currently sells advanced design sensors, and it intends to eventually manufacture and sell the ADLR system. ASC employs 10 people.

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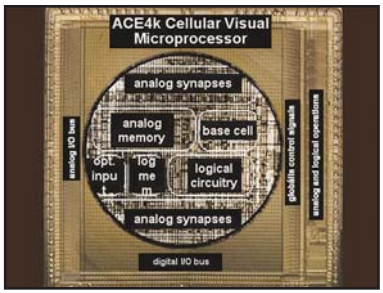

Cellular visual microprocessor chip

Analogic Computers Ltd.

BIO-INSPIRED CHIP CAPTURES AND PROCESSES IMAGES IN REAL TIME, UP TO 50,000 FRAMES PER SECOND

The CVM chip is being developed as an airbag sensor and integrated in the Bi-i System, which is a high frame rate, day and night vision system that will enable or disable the airbag according to the position and size of the driver.

Introduction

AnaLogic Computers Ltd. (Budapest, Hungary) and AnaFocus Ltd. (Seville, Spain) are developing a software/hardware environment and biology motivated algorithms for a new focal plane cellular visual microprocessor (CVM) chip, ACE16K, which will be applied as a smart sensor for MDA. The bio-inspired CVM, specifically the 128 x 128 chip that will be used by MDA, is a compact, low-power, ultra-high-speed visual system that can make decisions in real time. It can capture and process up to 50,000 frames per second (FPS) depending on the application. Current state-of-the-art digital technology can only process approximately 100 FPS. ACE16K can distinguish between real and fake targets in Earth's atmosphere or in space in milliseconds. The chip, combined with a smart sensor computer, is also capable of carrying out functions such as multiple target identification, analysis, and tracking on a fused video-flow.

The Tool

AnaLogic is developing cellular neural network (CNN)-based CVM technology. This technology mimics human visual sensing and neural processing. The CNN technology is based on a cellular processor array, which consists of numerous identical analog-processing elements that are arranged on a rectangular or hexagonal grid. Beyond the simple analog and logic computational unit, each element contains an optical sensor and memory.

Its Status

AnaLogic received funding from MDA for the algorithm and hardware development of the CVM technology. The company's United States arm, EUTECUS, submitted MDA SBIR proposals to continue development of the CVM

technology. AnaFocus and AnaLogic prepared and delivered two prototypes of the ACE16K Chip to MDA early this summer. Also funding the development efforts are NASA, the Hungarian government, and company revenue made from commercial projects.

CVM technology has multiple commercial applications. For example, AnaLogic is developing an airbag sensor. Most airbag injuries and deaths result from drivers leaning too close to where the airbag will be deployed or not properly using their seatbelts. The airbag sensor is an application of the Bi-i System, which is a high frame rate, day and night vision system that would enable or disable the airbag according to the position and size of the driver.

AnaLogic was founded in March 2000 by an international team of scientists from research institutions in Hungary, Spain, and the United States. The company intends to introduce visual computing based on cellular neural/nonlinear network technology. AnaLogic is a spinoff of the Computer and Automation Research Institute of the Hungarian Academy of Sciences (MTA-SZTAKI), which is the leading force in CNN technology worldwide. The company acquired rights to the technology from MTA-SZTAKI. AnaLogic is a strategic partner of AnaFocus Ltd, and works very closely with MTA-SZTAKI, which is funded by the Office of Naval Research and the European Commission.

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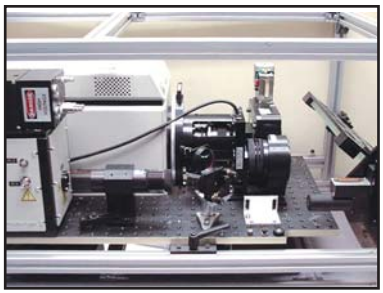
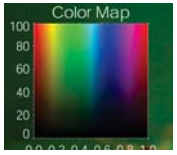


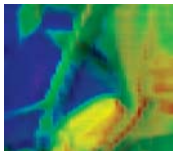
Polarimetric imaging streak tube LIDAR system

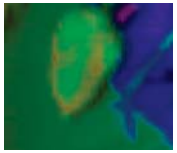
Areté Associates

PISTL PROVIDES POLARIZATION DATA WHILE SIMULTANEOUSLY CAPTURING 3-D IMAGES IN REAL TIME

The PISTL system is ideal for multiple military identification applications including target detection and identification, and land and ocean mine detection.







Introduction

Areté Associates (Tucson, AZ) is developing a polarimetric imaging streak tube LIDAR (PISTL) system, which provides 3-D imaging, ranging, and polarization data of a target simultaneously in real time. MDA funded the company to develop PISTL, which is an extension of Areté's 3-D imaging streak tube LIDAR (STIL) technology, for target detection and identification. The Navy funded the STIL technology to provide high spatial resolution measurements in the ocean for the detection of mines. PISTL adds a degree of polarization data set to the STIL imaging device. The PISTL system operates at 200 Hz and scans up to 30 km^2 per hour. The wide fan beam can be configured to scan different size areas with different resolutions; for example, the current system's beam is 140 meters wide and provides 25 cm spatial and range sampling from an altitude of 1 km. Measuring the amount of depolarization of laser light reflected off targets can

improve discrimination capabilities, especially when imaging through camouflage such as smoke, water, or a bright plume.

The Tool

PISTL is based on Areté's patented STIL technology, which is a 3-D imaging system that operates by projecting laser light in a fan-shape illumination. Any objects caught in the fan beam reflect the transmitted laser light back and are detected by the streak tube imaging system. The amount of time it takes for the laser light to return to the receiver is used to determine the depth and range of the object. The PISTL system, in addition, splits the transmitted laser light fan beam into co-polarized and cross-polarized states. These two orthogonal components are reflected back from the object and

measured simultaneously. Observing how the object changes the states of light polarization provides information about its material makeup. The PISTL system has a larger photocathode than other STIL systems to accommodate the two slits required for the polarimetric data. Both systems contain a streak tube with an integrated charged-coupled device (CCD) combining more than 12-bit digitization and sampling of up to 1,000 channels simultaneously.

Its Status

Areté's PISTL system is ideal for multiple military identification applications including target detection and identification, and land and ocean mine detection. A prototype of the system has been developed and will soon be tested on a helicopter flying 300 to 1,000 meters above the ground. With adequate funding the PISTL system can be reduced in size and applied to a missile seeker application in three to five years. The STIL system is already in use by the Navy for underwater mine detection programs. Founded in 1972, Areté has multiple offices in the United States that specialize in research projects for the government. The company employs about 160 people.

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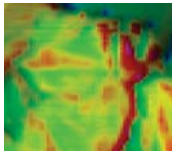
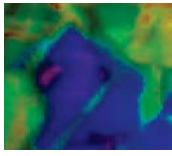

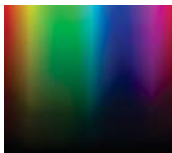

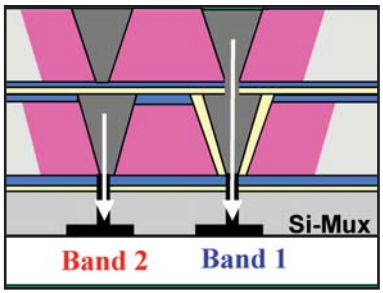

Detector cell high density vertically integrated photodiode

DRS Infrared Technologies, LP

TWO-BAND FOCAL PLANE ARRAY DETECTS INFRARED AND GUIDES INTERCEPTOR TO SOURCE

The original one-band HDVIP FPA was successfully integrated into the U.S. Army's Javelin Commanders Launch Unit and the Standard Advanced Dewar Assembly II.

Introduction

DRS Infrared Technologies, LP (DRS-IRT; Dallas, TX), a subsidiary of DRS Technologies, is developing a two-band mercury cadmium telluride (HgCdTe) infrared (IR) focal plane array (FPA) for missile seeker applications. MDA/Advanced Systems (AS) funded the company to use its High Density Vertically Integrated Photodiode (HDVIP) FPA technology, which fits the two-band requirements of the Standard Missile-3 (SM-3) interceptor for the Sea-Based Midcourse Defense (SMD) Element. The HDVIP FPA will detect and locate IR sources in its field of view and provide guidance to the interceptor. DRS' two-color and three-color FPA projects are part of the MDA/AS Advanced Passive EO/IR Sensor Technology Program. The two-color project started with funding from MDA/AS, and now is a joint effort among three MDA programs for

specific technology insertion. The project is executed by the Naval Research Laboratory, which is providing technical guidance and program coordination.

The Tool

The two-band HDVIP FPA's detector cell consists of two stacked layers of HgCdTe material. The composition of the HgCdTe material in each layer is adjusted so that it detects the spectral characteristics of a target in two different spectral bands. Therefore, when the HDVIP FPA detects the infrared radiation of a target in its field of view, two signals are simultaneously generated that reflect the spectral characteristic of the target in the two selected spectral bands of interest. The

addition of a second IR band enhances the capability to discriminate between exoatmospheric decoys, launch debris, and incoming threat warheads by estimating the temperature of the objects in the field of view. The HDVIP FPA also includes signal-processing functions, which will optimize the intercept scenario. For example, the FPA data update rate is alterable depending on the time line of the intercept. Multiple operational modes can be selected for high sensitivity requirements of point targets and high dynamic range needs for end-game guidance and tracking.

Its Status

DRS-IRT's two-band HDVIP FPA is in the prototype evaluation and producibility program phases. Integrated circuits in the device will be optimized over the next two years. The prototype FPAs will be delivered to MDA for system testing and demonstration. At the same time, MDA/AS is funding DRS to take its two-band HDVIP FPA technology one band further by developing a three-band structure. The company has already demonstrated the feasibility of simultaneous detection in three IR bands and now, with the assistance of NRL, is moving on to develop three-band HDVIP FPA prototypes that are suitable for demonstration.

DRS-IRT, formerly a Texas Instruments business unit, has been developing devices for the military since the 1960s. The original one-band HDVIP FPA was successfully integrated into the U.S. Army's Javelin Commanders Launch Unit and the Standard Advanced Dewar Assembly II. In 1998, DRS Technologies acquired DRS-IRT. DRS Technologies provides products and services to government and commercial customers worldwide.

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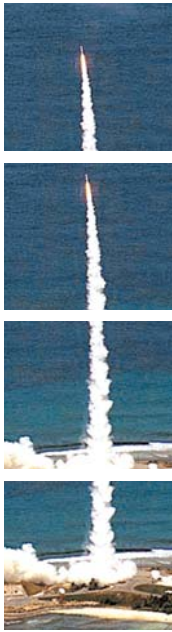
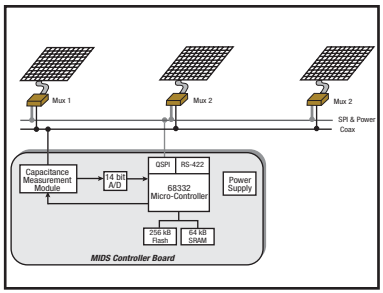


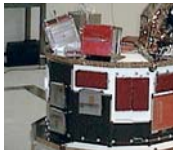


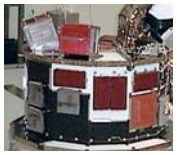
Micrometeoroid impact detection system

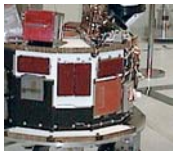
Innovative Dynamics, Inc.

RAD-HARD CAPACITANCE SENSOR MONITORS STRUCTURAL HEALTH OF WINGS AND SATELLITES

The ice sensor, based on technology from the MIDS program, has been transferred through a licensing agreement to BF Goodrich Aerospace, a manufacturer of pneumatic deicing boots for business and commercial aircraft.







Introduction

Innovative Dynamics, Inc. (IDI; Ithaca, NY), developed and distributes a capacitance-based structural health monitoring system for government and commercial applications. BMDO, now MDA, and NASA funded IDI to develop the system for accurate damage assessment of structures in space. IDI created the micrometeoroid impact detection system (MIDS), which can detect micrometeoroid debris that may damage or disable sensitive instruments exposed to the space environment, for use by the government. It is a radiation-hardened technology that can measure the number, size, location, and time of micrometeoroid impacts. Commercially, the company has applied this technology to the development of an ice sensor, which measures and quantifies non-uniform, heterogeneous ice typically found on aircraft leading edges and top wing surfaces. The ice sensor, which is currently being used by the aeronautical industry, automatically alerts pilots to the formation of ice when flying.

The Tool

MIDS detects micrometeoroid impacts using a thin capacitance sensor array grid attached to the outer surface of the satellite. When the film is perforated in any way, the array element capacitance is reduced proportional to the area of the damage. Software compares the current measurement with past measurements to detect a reduction in capacitance.

Similar ultra-sensitive capacitance electronics are used in IDI's thin-film ice sensor placed along the surface of the aircraft wing to detect small changes in the dielectric constants of air, ice, and water. Noting the differences in dielectric constants allows the sensor system not only to discern ice from water, but also to track the ice from its onset to a critical thickness threshold.

Its Status

On June 7, 2000, the Space Technology Research Vehicle (STRV-2), a multinational, multi-agency set of space experiments managed by the MDA/Advanced Technology Materials, Structures, and Power program, was launched from Vandenberg Air Force Base. The Electronics Test Bed—a research program on STRV-2 sponsored by NASA's Jet Propulsion Laboratory—housed MIDS, which measured the micrometeoroid impacts in low- and mid-Earth orbit environments. On March 15, 2002, the STRV-2 mission ended successfully. NASA is currently analyzing the information acquired from the MIDS experiment.

The ice sensor that was developed based on work from the MIDS program has been transferred through a licensing agreement to BF Goodrich Aerospace, a manufacturer of pneumatic deicing boots for business and commercial aircraft.

Founded in 1988, IDI is a technology development and engineering services company that specializes in electronic, sensor, signal processing, and electromechanical systems. The company employs 15 people.

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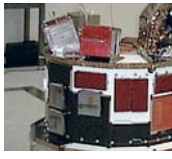

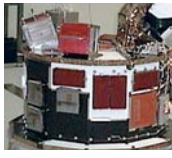

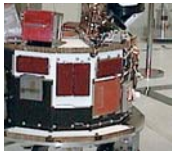

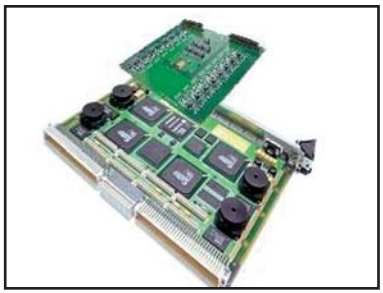

Silicon brain

Irvine Sensors Corporation

NEURAL NETWORK TECHNOLOGY EMULATES THE HUMAN BRAIN

The Silicon Brain is capable of locating a face in a crowd faster than current facial recognition systems by 100-fold, yet is comparably priced.

Introduction

Irvine Sensors Corporation (ISC; Costa Mesa, CA) is leading an MDA-funded effort to develop a very low power, low weight, small volume interceptor technology capable of discriminating replicating- and enveloping-balloon decoys. An ultra-violet LADAR capable of acquisition and tracking from 100 km, discrimination of the target with centimeter resolution from 30 km, and determination of aimpoint from 10 km will be produced using a combination of previously developed MDA-funded technologies.

The Tool

The Silicon Brain Architecture is a neural network the size of a shoebox with the same volumetric efficiency as the human brain. Thinned and stacked integrated circuitry chips emulate the highly integrated neural circuitry of the brain. The key to this concept is Irvine Sensor's unique chip stacking and crossbars, which enable interconnects within and between stacks.

The company's chip-stacking technology, 3-D Artificial Neural Network (3DANN), is a sugar-cube sized stack of custom neural chips and application specific integrated circuits (ASICs) that can provide petaflop performance (quadrillions of operations/second) using less than 10 watts of power. The company enhanced 3DANN by incorporating the 3-D Field-Effect Transistor Interconnect Technology (3DFET), which serves as the intermediate layer between the FPGAs in the chip stack. In addition to the neural network hardware and chip-stacking

technology, Irvine has written neural network software to optimize the 3DANN. This neural network engine is then integrated with a sensor or sensor suite, including imaging optical "retinas," auditory "cochlea," and digital or analog buses.

The Silicon Brain technology is being combined with TREX Enterprise's Photoconductor on Active Pixel (POAP) detector technology to develop the discriminating interceptor solution. The POAP detector will be extended to the ultraviolet to enable high-resolution active imagery in the focal plane arrays. An active imaging readout integrated circuit is being developed to provide the LADAR imaging interface between TREX's POAP detector and Irvine Sensors' Silicon Brain processors.

Its Status

BMDO, now MDA, funded Irvine Sensors through the SBIR program to provide a silicon version of the human brain to execute the sensing, discrimination, and systems control functions of ballistic missile defense. MDA awarded the company a 2002 SBIR Phase I contract to develop the discriminating interceptor solution using the Silicon Brain technology combined with TREX's POAP technology, which was also funded by MDA. The Silicon Brain technology is currently available to MDA, and it will arrive on the commercial market in the fall of 2003. Irvine Sensors is initially entering the commercial market through direct sales to image processing original equipment manufacturers for facial recognition. The Silicon Brain is capable of locating a face in a crowd in real time—faster than current facial recognition systems by 100-fold—yet comparable in price.

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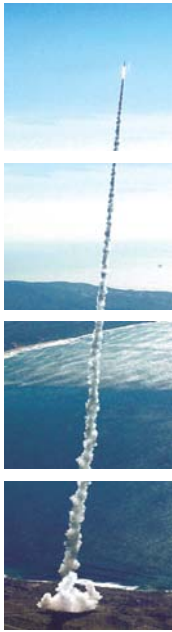

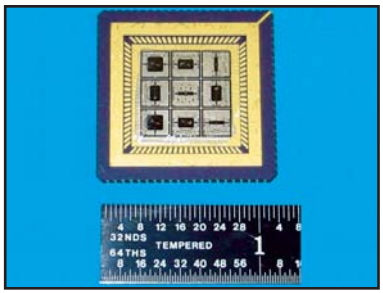

Micro-electro-mechanical systems accelerometers

Milli Sensor Systems and Actuators, Inc.

MEMS ACCELEROMETERS MAINTAIN STABILITY AND RESOLUTION IN HIGH G-FORCE

The MEMS accelerometer is being integrated into an inertial measurement unit that may be used to navigate all missiles, munitions, and submunitions once they are fired.

Introduction

Milli Sensor Systems and Actuators, Inc. (West Newton, MA), is developing a dynamically tuned accelerometer by borrowing technology used on gyroscopes and applying it to micro-electro-mechanical systems (MEMS) accelerometers. BMDO, now MDA, funded the company to develop smaller, lower-cost, and more-rugged MEMS accelerometers for inertial navigation systems in missiles and space. The accelerometer was integrated into a prototype inertial measurement unit (IMU) that is capable of measuring motion in all six degrees of freedom with a single chip. The company's MEMS accelerometers are operable in tens of thousands of g-forces (the force of Earth's gravity) while maintaining high stability and resolution.

The Tool

Milli Sensor's accelerometer provides the cost and size benefits of a MEMS accelerometer but has the ruggedness, resolution, and stability that a MEMS accelerometer normally cannot achieve. A conventional MEMS accelerometer with high sensitivity has a soft flexure allowing the device to get a bigger deflection per given acceleration input. However, a soft, thin flexure means the device will break upon experiencing high-g shock.

Milli Sensor went a different route and developed a method of producing MEMS

accelerometers that stems from dynamically tuned gyroscopes. To obtain high sensitivity, the accelerometer contains a pendulum that is oscillated about an axis, which allows the flexure to be soft yet, mechanically, remain very rigid to handle high-g forces.

Its Status

Milli Sensor is now being funded by the Air Force to develop an integrated IMU that incorporates the MEMS accelerometer technology. The IMU is a six degrees of freedom measurement unit that has three gyros and three accelerometers all on the same chip. It could be used to navigate small artillery projectiles once they are fired. The Air Force is part of an overall joint forces effort called the High-g MEMS IMU Program to develop a high-g, high-accuracy IMU that can be used in all missiles, munitions, and submunitions. Milli Sensor is developing the IMU so it will qualify for that program. The company has developed and tested the first IMU. Since it was successfully integrated, Milli Sensor is currently concentrating on making better components to improve the capabilities of the IMU.

The company's overall vision is to develop instruments that can be integrated in various ways to fit different applications. The founders of Milli Sensor are all designers of high performance inertial measurement instruments. They develop the designs for guidance instruments, components, and inductors and work with foundries, such as Tanner Research Laboratories and ISSYS, to fabricate the technology. Milli Sensor was founded in 1994 and has seven full-time and six part-time employees.

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Quantum well infrared photodetector camera

NASA's Jet Propulsion Laboratory

QWIP CAMERA OFFERS INFRARED SURVEILLANCE AT LONG- AND MID-WAVELENGTHS

The QWIP camera, an IR camera based on QWIP technology, has identified lingering hot spots—typically undetectable with the naked eye—leftover from forest fires, and it is being used in medical applications for measuring skin temperature and heart imaging.

Introduction

NASA's Jet Propulsion Laboratory (JPL; Pasadena, CA) has developed and proven the capabilities of its quantum well infrared photodetector (QWIP) technology. QWIPs have achieved large format, low frequency noise performance, high operability, and high uniformity with a high-yield fabrication process. BMDO, now MDA, Advanced Systems funded JPL to develop imaging cameras for ground- and space-based infrared (IR) surveillance at long-wavelengths to identify ballistic missiles, which have peak emissions in the 8- to 15-micron region when the hot rocket engine is not burning. JPL is now using QWIP technology to develop 1024 x 1024 pixel mid-wavelength IR (MWIR) QWIP focal plane arrays (FPAs) and MWIR and long-wavelength IR (LWIR) pixel co-located 320 x 256 format dual band QWIP FPAs for MDA's Airborne Laser (ABL) element in the missile defense system. The ABL is a

weapons class laser installed into a modified 747 Boeing aircraft that will seek and destroy ballistic missiles soon after launch.

The Tool

JPL's QWIP technology is based on gallium arsenide (GaAs) and aluminum GaAs materials. IR photodetectors are based on multi-quantum-wells, which are artificial structures that are extremely sensitive to temperatures as small as 1/100 of a degree. The atom-size quantum wells are packed together in high densities allowing the QWIPs to efficiently capture IR radiation.

Its Status

JPL is delivering the first QWIP FPAs to MDA for ground-testing in December 2003. Researchers at JPL's Microdevices

Laboratory are continuously developing and enhancing the QWIP technology, which is being used for a large variety of commercial and government applications. The QWIP camera, an IR camera based on QWIP technology, has identified lingering hot spots—typically undetectable with the naked eye—leftover from forest fires, and it is being used in medical applications for measuring skin temperature and heart imaging. The QWIP camera also has potential in homeland security applications such as airborne surveillance for national border patrol.

JPL was founded in the 1930s by a California Institute of Technology (CalTech) professor. The laboratory remains under the management of CalTech and performs research in such areas as robotic exploration, communication, and the environment.

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Sherlock hyperspectral camera

Pacific Advanced Technology

HYPERSPECTRAL CAMERA DETECTS MULTIPLE BANDS SIMULTANEOUSLY

PAT's Sherlock Camera was developed as a gas leak detection camera for various hydrocarbon leaks from facilities such as oil refineries, gas-processing plants, and petro-chemical and pharmaceutical plants.

Introduction

Pacific Advanced Technology (PAT) is developing the Sherlock Hyperspectral Camera, which is based on its BMDO—now MDA—funded Image Multispectral Sensing (IMSS) technology. PAT recently received a 2002 MDA SBIR Phase I contract to develop a conceptual design that will allow a missile seeker to detect multiple spectral bands simultaneously. This technology will utilize the Sherlock Camera technology. It will help discriminate between a true missile target and decoys during the mid-course phase and differentiate a real missile launch from false alarms such as smoke stacks and lightning during the boost phase.

The Tool

The Sherlock Hyperspectral Camera is based on PAT's Image Multispectral Sensing (IMSS) technology, which combines a diffractive imaging spectrometer and an adaptive tunable filter. The IMSS technology can image a scene in three dimensions—two spatial and one spectral—to build a multispectral spatial imaging cube of data. The technology has a high throughput value of greater than 85 percent because it uses a single lens to perform both imaging and dispersion, enabling a very small, light weight, robust, and low-cost imaging spectrometer. PAT integrated its IMSS technology with Indigo Systems Corporation's sensor engine, and a viewer to create the lightweight and robust Sherlock Camera. Each frame of the camera is a spectral color, and subsequent frames can either contain different or identical colors if the IMSS lens is scanned along the optical axis. This function enables the selection and analysis of specific bands and regions of interest, and allows the camera to settle on a single spectral band indefinitely.

Its Status

PAT developed the IMSS technology under an SBIR contract from the Air Force Space Division. Since then, BMDO, now MDA, funded PAT through numerous SBIR contracts to further develop the IMSS technology for the accurate and quick detection of theater missiles clouded by clutter. PAT's most recent MDA SBIR contract is for a conceptual design of a seeker based on the IMSS technology. The goal is to develop a technology that will have the capability to detect multiple spectral bands simultaneously.

PAT's Sherlock Camera is drawing interest from the petroleum industry. Originally, the technology was developed as a gas leak detection camera for imaging various hydrocarbon leaks from facilities such as oil refineries, gas-processing plants, and petrochemical and pharmaceutical plants. However, the camera can be adapted to other applications such as chemical/biological agent detection and identification, environmental monitoring, reconnaissance and surveillance, and numerous research and development applications.

British Petroleum (BP) worked with the Gas Technology Institute to provide funding and facilities for testing the camera. Shell Petroleum and a corporation in Sweden have also expressed interest in the technology. The Sherlock Camera was tested at BP facilities in April 2003 and PAT anticipates having a unit for sale in spring 2003. The camera will cost between $40,000 and $80,000, depending on how many are manufactured.

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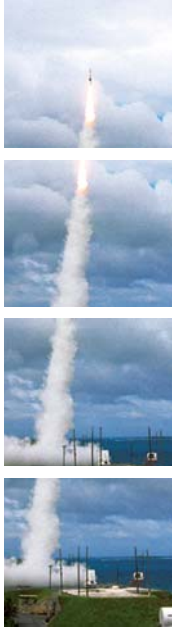

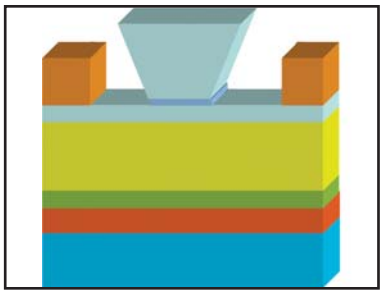

Heterodimensional sensor

Photonics Laboratories, Inc.

SMALLER PHOTODETECTORS DEVELOPED USING 5- TO 10-MICRON-SIZE HETERODIMENSIONAL SENSORS

A demonstration prototype of a photoconductor developed using heterodimensional sensors was built, and the company is now seeking funding and a semiconductor manufacturer to assist with the creation of a production prototype.

Introduction

Photonics Laboratories, Inc. (Philadelphia, PA), is developing heterodimensional sensors for fabricating small, high-speed, and low noise photodetectors. MDA and the National Science Foundation (NSF) funded the development of the technology. Photonics Laboratories' sensor design can lead to more effective focal plane arrays for missile seekers. The small size of the heterodimensional sensors—5 to 10 microns—enables more photodetectors to be incorporated in a two-dimensional array. The sensors contain quantum well structures, which enable an improved signal-to-noise ratio, with very low dark current (less than one pico amp). Photonics Laboratories' prototype photodetectors are currently sensitive between 700 and 900 nm, however a newly designed photodetector is under testing for application in the 1300- to 1550-nm range, and will soon be available as a demonstration prototype.

The Tool

The effects of electron confinement determine the characteristics generated by Photonics Laboratories' optoelectronic devices. The devices are based on the same structure used in high electron mobility transistors (HEMT), a modulation-doped heterojunction structure, which produces a reduced two-dimension electron gas (2DEG). Heterodimensional devices are created when the electron gas is contacted by a system of a higher dimension. Sharing the same growth structure as the HEMT, heterodimensional devices are monolithically integrative. The 2DEG concentration and the vertical electric field that confines it have a strong effect on both dark current and light response.

Its Status

Photonics Laboratories currently has a demonstration prototype of the photodetector, however the company is seeking funding and a semiconductor manufacturer to assist with the development of a production prototype. Upon completion of the prototype, the product can be available within six months. A single photodetector production prototype will cost between $200,000 and $250,000.

Founded in 1995, Photonics Laboratories is a research and development company that specializes in fiber optics and photonics devices and systems. The company employs 12 people.

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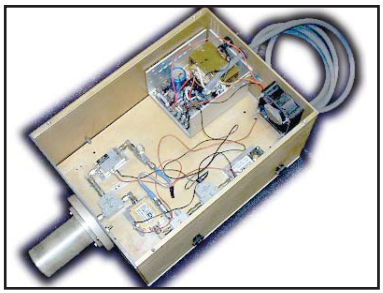

Gamma radiation spectrometer

Sentor Technologies, Inc.

RADIATION DETECTOR OFFERS HIGH ENERGY RESOLUTION, ENABLING DISTINCTION BETWEEN RADIOACTIVE ATOMS

A prototype radiation detector is developed, however the company needs help packaging it with a streamlined appearance for its commercial applications such as emergency room response, treaty inspection, and environmental oversight.

Introduction

Sentor Technologies, Inc. (Glen Allen, VA), is developing an optical semiconductor-based gamma radiation spectrometer. The BMDO, now MDA, SBIR program funded the company to develop the radiation detector, which could be used for surveillance purposes in missile defense. The device can detect hidden missiles equipped with nuclear warheads or containing radioactive materials.

Upon completion, Sentor's radiation detector is expected to provide high energy resolution, operate at room temperature, and have a large working volume. High energy resolution is important because it allows a user to distinguish between two different radioactive atoms that might be very similar in terms of released energy. Room-temperature operation eliminates the need for additional cooling components, and large volume enables the capture of deeply penetrating gamma rays. Sentor's device also offers a speed advantage over traditional detectors, which use DC electric fields. As opposed to relying upon the relatively slow moving electron cloud of charge carriers, Sentor's detector relies on the electromagnetic effect of faster moving photons and the resonance of an AC field at microwave frequencies.

The Tool

Sentor's radiation detector creates signals through changes in the electromagnetic field, which requires no electrical contact with the semiconductor. The device relies on the absorption of electromagnetic energy and microwave resonance in a specially designed cylindrical cavity. The cavity includes a semiconductor that absorbs gamma-ray photons—energy that is naturally emitted from the nucleus of radioactive atoms. Changes that occur

within the cavity alter its resonance frequency. So when a photon is absorbed within the semiconductor, the semiconductor conductivity increases, altering the resonance condition of the cavity. To generate a reading, Sentor's radiation detector simply monitors which frequencies are absorbed by the cavity and which frequencies are reflected.

Its Status

Sentor has developed a prototype radiation detector and is currently building special circuitry to stabilize the device for environmental changes. The company will need help packaging the prototype so that it is a marketable product with a streamlined appearance. Commercial applications of the detector include emergency response, treaty inspection, and environmental oversight. The company is interested in possibly licensing the technology to be incorporated into medical equipment for use in nuclear medicine imaging.

Founded in 1994, Sentor specializes in the design and development of functional and smart solid-state devices.

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"The Missile Defense Agency has funded land-, sea-, air-, and space-based sensor technology to support the ballistic missile defense system and perform the duties that go beyond human capability."

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