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Infrared Sensors, Devices, and Applications VII

Paul D. LeVan
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8 Applications II
Paul D. LeVan, Air Force Research Laboratory (United States)
Arvind I. D'Souza, DRS Sensors & Targeting Systems, Inc. (United States)

Introduction

Noise and detectivity of InAs/GaSb T2SL 4.5 µm IR detectors
Andrzej Kolek, Lukasz Ciura, Rzeszów Univ. of Technology (Poland); Krzysztof Czuba, Agata Jasik, Institute of Electron Technology (Poland); Jaroslaw Jurenczyk, Institute of Electron Technology (Poland), VIGO System S.A. (Poland); Iwona Sankowska, Janusz B. Kaniewski, Institute of Electron Technology (Poland)

A thorough noise analysis was conducted for this detector for the various currents relating to the diffusion, generation-recombination, shunt, and tunneling processes. Hooge formula for 1/f noise associated with shunt and trap-assisted tunneling currents described in detail. Temperature varied over a wide range (77 to 230K) for noise measurements. Good model fittings found over a range of forward and reverse bias. Generation-recombination noise quantified in terms of corner frequency, itself a function of temperature in accordance with a thermally activated process. Activation energies of various traps in the material were also determined. In response to a question, it was noted that the levels of 1/f noise in these devices were approximately comparable to PV mercury cadmium telluride.

Resonantly enhanced infrared detectors based on type-II superlattice absorbers
Michael D. Goldflam, Emil A. Kadlec, Benjamin V. Olson, John F. Klem, Samuel D. Hawkins, S. Parameswaran, Wesley T. Coon, Gordon A. Keeler, Torben R. Fortune, Anna Tauke-Pedretti, Joel R. Wendt, Eric A. Shaner, Paul S. Davids, Jin K. Kim, David W. Peters, Sandia National Labs. (United States)

In this study of Ga-free superlattice detectors, detector thickness was noted as favorable for absorption, but less desirable for reducing the electric field strength. Sophisticated on and off resonance characterizations were performed with E-field mapping. These resonances can be tailored, and a broadened spectral response is possible with the multiple antenna geometries that were considered. An idea for dualband capability (spatial over surface of FPA) was presented. In response to question, reducing the dielectric to improve efficiency will be investigated. Overall, addition of the resonant nano-antenna leads to x4 to5 responsivity increase.

Theoretical simulation of mid-wave type-II InAs/GaSb superlattice interband cascade photodetector
Klaudia Hackiewicz, Tetina Manyk, Piotr Martyniuk, Jarosław Rutkowski, Wojskowa Akademia Techniczna im. Jaroslawa Dabrowskiego (Poland)

A novel cascade detector was investigated as a means to achieve higher sensitivity at higher temperatures. Extraction of valence band electrons for this interband cascade architecture, where many photons produce a single electron, is needed for detection. Nevertheless, sensitivity was found to improve as number of stages was increased, and this relates in part to a reduction of shot noise.

Theoretical characteristics were found to agree well with those experimentally measured, assuming that transport in the absorber region is determined by dynamics of intrinsic carriers. Carrier lifetimes were measured at three separate temperatures; response times for this detector are very fast and on the scale of nano-seconds. No studies of 1/f noise have been performed as yet.

Effects of 4.5 MeV and 63 MeV proton irradiation on carrier lifetime of InAs/InAsSb type-II superlattices
Emil A. Kadlec, Michael D. Goldflam, Edward Bielejec, Jin K. Kim, Benjamin V. Olson, John F. Klem, Samuel D. Hawkins, Johnathan Moussa, Peter A. Schultz, Sandia National Labs. (United States); Christian P. Morath, Geoffery D. Jenkins, Vincent M. Cowan, Air Force Research Lab. (United States); Eric A. Shaner, Sandia National Labs. (United States)

Protons of 4.5 and 63 MeV were applied to superlattice detectors over a range of fluence levels, and microwaves employed for time-resolved reflectance measures. Excess carrier densities could be determined down to relatively low concentrations. Determination of diffusion currents also possible. Effects of 100kRad radiation very pronounced on minority carrier lifetime. Annealing timescales were discussed, and the importance of quickly assessing test damage was underscored. The damage mechanism might relate to an increase in the Shockley Read Hall mechanism, and strategies for mitigation are under investigation. Statistical significance of differences in slopes of damage vs dose between two proton energies needs to be determined, since the two slopes are similar if not identical.

Extraction of minority carrier diffusion length of MWIR Type-II superlattice *nBp* detector
Zahra Taghipour, The Univ. of New Mexico (United States); Alireza Kazemi, The Ohio State Univ. (United States); Stephen Myers, SKINfrared LLC (United States); Priyalal S. Wijewarnasuriya, U.S. Army Research Lab. (United States); Sen Mathews, The Univ. of New Mexico (United States); Elizabeth Steenbergen, Christian P. Morath, Vincent M. Cowan, Gamini Ariyawansa, John Scheihing, Air Force Research Lab. (United States); Sanjay Krishna, The Ohio State Univ. (United States), Univ. of New Mexico (United States), SKInfrared LLC (United States)

A model for the external spectral quantum efficiency is employed to extract the minority carrier diffusion length of a unipolar nBp Type-II superlattice of InAs/GaSb, operating as a MWIR detector. The presenter explained why differences in lateral and transverse mobilities should be present, since the lateral direction does not experience the superlattice. Employed the Hovel expression for diffusion length extractions; diffusion calculation in accord with Einstein relation. Separate quantum efficiency calculations performed for p and n regions. Absorption and diffusion length measurements were made at three temperatures from 80 to 150K, all at bias of 0.2V. A question was asked on the impact of ignoring surface recombinations, and answered that its inclusion would lead to lower bound for the

calculation on the actual diffusion length. The diffusion length was found to exceed the device thickness; more analysis underway along these lines.

Session 2:
SLS & Barrier Detectors II
Session Chairs:
Sachidananda R. Babu, NASA Goddard Space Flight Ctr. (United States);
Arvind I. D'Souza, DRS Sensors & Targeting Systems, Inc. (United States)

Active modulation of surface plasmon polaritons at degenerate semiconductor interfaces
Raj K. Vinnakota, Dentcho A. Genov, Louisiana Tech Univ. (United States)

No presentation.

Distance and temperature dependent plasmon-enhanced carrier generation and diffusion in InAs/InGaAs/GaAs near-infrared photodetectors
Terefe Habteyes, Sharmin Haq, Sadhvikas Addamane, Bijesh Kafle, Ganesh Balakrishnan, The Univ. of New Mexico (United States); Danhong Huang, Air Force Research Lab. (United States)
Plasmonic gold nanorods (AuNRs) are used to enhance generation of charge carriers and photon emission by InAs/InGaAs/GaAs quantum dots-in-a-well semiconductor heterostructures, for which the measured and calculated scattering spectra are compared. First, an overview of excitonic plasmonic interactions was provided. Relations to polarizability resonances were described. Techniques included near-field optical signal probing with AFM, and photo luminescence measures at both room and cryogenic temperatures. Some experimental results were initially confusing yet theoretical calculations (by Dr Danhong Huang) were found to exhibit similar trends and show reasonable agreement with data. Explanations were provided in response to a question on dielectric constant behavior with temperature.

Also relevant to this session is the following poster presentation and accompanying proceedings article

Effect of antimony segregation on the electronic properties of InAs/InAsSb superlattices,
H. J. Haugan, F. Szmulowicz, J. J. Hudgins, L. E. Cordonnier, and G. J. Brown.
The paper describes Ga-free InAs/InAsSb superlattice (SL) materials and the compositional changes that have been attributed to antimony segregation. The authors explore epitaxial conditions that can mitigate this segregation in order to produce higher-quality SL materials for higher levels of detector performance.

Session 3:
Applications: Medical
Session Chairs:
Paul D. LeVan, Air Force Research Lab. (United States);
Priyalal Wijewarnasuriya, U.S. Army Research Lab. (United States)

The photonic device for integrated evaluation of collateral circulation of lower extremities in patients with local hypertensive-ischemic pain syndrome
Volodymyr S. Pavlov, Vinnitsa State Technical Univ. (Ukraine); Yurii O. Bezsmernyi, SRI of Invalid Rehabilitationon on the base of National Pirogov Memorial Medical University (Ukraine); Sergey M. Zlepko, Vinnitsa State Technical Univ. (Ukraine); Halyna V. Bezsmertna, SRI of Invalid Rehabilitationon on the base of National Pirogov Memorial Medical University (Ukraine)

Optical radiation reflected from bio-tissue can be employed in the process of the assessment of the regional hemodynamics state in patients with local hypertensive-ischemic pain syndrome in the amputation stumps of lower extremities, by applying the method of photo-plethysmography. Absorption of infrared laser radiation by skin layers includes contributions from blood and red cells in particular. By fiber coupling both the illumination and reflected light paths, measurements were obtained. Results are reported for a group of human subjects, both before and after blood circulation therapy. Future plans were described.

In vivo noninvasive detection of blood glucose by near-infrared spectroscopy with machine learning techniques
Siman Zhang, Siqi Liu, Ting Xie, Peng Sun, Chang Wang, Huaye Li, Zhenrong Zheng, Zhejiang Univ. (China)

No presentation.

Photoacoustic signal detection using interferometric fiber-optic ultrasound transducers
Amanda D. Salas-Caridad, Geminiano Martinez-Ponce, Rodolfo Martinez Manuel, Centro de Investigaciones en Óptica, A.C. (Mexico)

The cross-section of a metallic sample was photo-acoustically imaged using a pulsed nanosecond laser as the excitation source and a fiber-optic hydrophone system to acquire the pressure signal. In order to reconstruct the image, a time set of ultrasound signals acquired in a circular scan around the sample was used as inputs to the time-reversal equations. Fabry Perot techniques were employed, with the experiment conducted in water tank. The resulting faint, greyscale image was able to reproduce dimensions of the metallic device with very good accuracy. Conclude that this transmission method is workable and that shape recovery is possible. Much analysis was conducted to ascertain that local heating was below critical levels, that stress effects are negligible, and the absence of chemical reactions.

Session 4:
Detectors, FPAs, and Calibration I
Session Chairs:
Ashok K. Sood, Magnolia Optical Technologies, Inc. (United States);
Sachidananda R. Babu, NASA Goddard Space Flight Ctr. (United States)

Extended wavelength InGaAs SWIR FPAs with high performance
Xue Li, Tao Li, Chunlei Yu, Hengjing Tang, Shuangyan Deng, Xiu-Mei Shao, Shanghai Institute of Technical Physics of the Chinese Academy of Sciences (China); Yonggang Zhang, Shanghai Institute of Microsystem and Information Technology,Chinese Academy of Sciences, Shanghai (China); HaiMei Gong, Shanghai Institute of Technical Physics of the Chinese Academy of Sciences (China)

Focal plane arrays comprised of SWIR InGaAS PIN detectors fabricated with molecular beam epitaxial growth were described. Perimeter to area studies were conducted over the range of 50 to 200 μm diameters. The 512x256 ROIC incorporates a CTIA unit cell (with correlated double sampling and integrate-while-read capabilities). Bulk dark current levels were determined over a range of temperatures that approaches room temperature. A superlattice structure was incorporated in the detector architectures as an e-barrier; questions on contributions of this layer to dark current were addressed. Noteworthy percentage operability was achieved for the FPAs.

640x512 pixel InGaAs FPAs for short-wave infrared and visible light imaging
Xiu-Mei Shao, Bo Yang, Songlei Huang, Yang Wei, Xue Li, Xianliang Zhu, Tao Li, Yu Chen, HaiMei Gong, Shanghai Institute of Technical Physics of the Chinese Academy of Sciences (China)

The author noted the landmark passage of 10 years of development of InGaAs (with traditional 1.7 μm cutoff) in China. The InP substrate was removed after detector growth to improve the visible wavelength response by mechanical thinning and chemical wet etching. Very high quantum efficiency (90%) was achieved at 1.55 μm; quantum efficiency at 0.5 μm was enhanced to 15%. The FPA operation is at a temperature of 293K.

Life test of the InGaAs focal plane arrays detector for space applications
Xianliang Zhu, HaiYan Zhang, Xue Li, ZhangCheng Huang, HaiMei Gong, Shanghai Institute of Technical Physics of the Chinese Academy of Sciences (China)

Interesting accelerated life test protocol was employed to address space application suitability and determine failure rates or Mean Time to Failure (MTTF), beginning with single pixel studies at elevated (stressing) temperatures. Some failures were attributed to disconnections of indium bump interconnects at elevated temperatures. Including three FPAs in the study results in good statistics

and allows prediction of confident mean times to failure, as well as activation energy.

Session 5:
Detectors, FPAs, and Calibration II
Session Chairs:
Paul D. LeVan, Air Force Research Lab. (United States);
Ashok K. Sood, Magnolia Optical Technologies, Inc. (United States)

Mid-infrared photo detector using pyroelectric response of $LiNbO_3$
Kavitha K. Gopalan, ICFO - Institut de Ciències Fotòniques (Spain); Davide Janner, Politecnico di Torino (Italy); Sebastien Nanot, Romain Parret, Mark B. Lundeberg, Frank H. L. Koppens, Valerio Pruneri, ICFO - Institut de Ciències Fotòniques (Spain)

The paper describes the non-invasive use of breath analysis for disease diagnostics. With a graphene layer mounted atop LiNbO3, the researchers realized improved TCR with graphene imparting a pyroelectric effect (as opposed to a voltage effect in LiNbO3 alone). Equal and opposite charge distribution was noted in the structure and may be exploited. Working between 1000 and 1400 wavenumbers with chopped laser input, the detector achieves a NEDT of 0.2 K. Questions asked on performance of the combination of the two materials verses the level of performance of LiNbO3 alone, in terms of levels of sensitivity.

Low dark current p-on-n technology for space applications
Nicolas Péré-Laperne, SOFRADIR (France); Nicolas Baier, Cyril Cervera, Jean-Louis Santailler, Clément Lobre, CEA-LETI (France); Christine Cassillo, Jocelyn Berthoz, Vincent Destefanis, Diane Sam-Giao, Adrien Lamoure, SOFRADIR (France)

Low dark current was noted for p on n diodes operating in the VLWIR HgCdTe (12.5µm at 40K) made with LPE and In doping implants. Two designs, one of which incorporates improvements for wider reverse bias region. Results below the "Rule 07" dark current densities were found, notably with a slope vs inverse temperature that differs from the rule. Diffusion limited performance noted for temperatures down to at least 80 K. A drop in QE is was found for this absorber layer thickness as the temperature is lowered to 40K, due to the decrease and non-optimization of the diffusion length at the lower temperature. Low 1/f noise found for the detector array when hybridized with a readout integrated circuit with CTIA unit cell.

Germanium photodetectors fabricated on 300 mm silicon wafers for near-infrared focal plane arrays
Ashok K. Sood, John W. Zeller, Magnolia Optical Technologies, Inc. (United States); Caitlin Rouse, Pradeep Haldar, Harry Efstathiadis, SUNY Polytechnic Institute (United States); Nibir K. Dhar, U.S. Army Night Vision & Electronic Sensors Directorate (United States)

It was again stressed that SiGe offers prospects of economy of scale due to growth on 12" substrates. Even though the level of performance cannot compete with more expensive InGaAs alternative, the potential cost savings for each FPA makes this a viable alternative for many applications.

Session 6:
New Techniques, Optical Fibers, Lasers
Session Chairs:
Paul D. LeVan, Air Force Research Lab. (United States);
Ashok K. Sood, Magnolia Optical Technologies, Inc. (United States)

Wave study of compound eyes for efficient infrared detection
Takiyettin O. Kilinc, Roketsan A.S. (Turkey), TOBB Univ. of Economics and Technology (Turkey); Zeki Hayran, TOBB Univ. of Economics and Technology (Turkey); Hasan Kocer, National Defense University (Turkey); Hamza Kurt, TOBB Univ. of Economics and Technology (Turkey)

Compound eyes and ommatidia with cornea located in the longitudinal sense lead to biologically inspired concepts of locating layers of graphene in the longitudinal direction along a slowly converging light bundle; the light channeling was described in detail. The wave analysis that was performed is in accord with the Maxwell Equations. Finite Difference Time Domain approaches employed for concept optimization. The 2.2% graphene efficiency can be exploited to achieve 50 to 70% effective efficiency for the wave structures in the application.

Probing infrared detectors through energy-absorption interferometry
Dan Moinard, Stafford Withington, Christopher N. Thomas, Univ. of Cambridge (United Kingdom)

The author described radiation properties over the electro-optical and radio frequency regions, noting the prevalence of single mode in microwave regions and of few and multi-mode in IR, which inspires coherent radiation concepts. In this case, a concept was motivated for an infrared source pair on the face of a pixel, with an adjustable phase shift between them. Detector spatial response function can be determined by this approach. Methods were shown to exist for recovery of the correlation term and the other interference parameters of interest to the detector characterization. Moreover, the detector response function can be decomposed into the natural modes for which the detector is incoherently sensitive to power. Hardware setup on optics table will lead to additional substantiating measurements in the coming year.

Frequency-selective surfaces for infrared imaging
Emeline Lesmanne, François Boulard, CEA-LETI (France); Roch Espiau de Lamaestre, MINATEC (France); Sylvette Bisotto, Giacomo Badano, CEA-LETI (France)

This research was motivated by the difficulty of fabrication of dualband infrared FPAs of different vertical composition within each pixel to achieve the two cutoff wavelengths. A thin metallic sheet of perforated apertures is filled with a high-index dielectric material. Each aperture behaves as a separate resonator, with size determining the transmission wavelength. In this approach, metallization and openings lead to spatial filter variations over 2x2 blocks of traditional infrared pixels. The resulting localized modes are of the needed TE type. Infrared frequency-selective surface embodiments have been quantified with values of Q that suggest 3 and 4-wavebands of useful spectral widths are possible by varying the geometry of the apertures.

Plasmo-thermomechanical suspended nanowire array detectors for mid-infrared spectrum
Qiancheng Zhao, Mohammad W. Khan, Univ. of California, Irvine (United States); Parinaz Sadri-Moshkenani, Univ. of California Irvine (United States); Rasul Torun, Imam-Uz Zaman, Ozdal Boyraz, Univ. of California, Irvine (United States)

Fishbone structures of nanowires act as absorbers for IR radiation and are used with a silicon nitride waveguide to create leaky wave radiation that may be detected. Structures that include approximately 10 nanowires appear theoretically optimal and have been fabricated. Designs at 0.79 and 4.3 μm have been developed, allowing for scaling analysis. Performance has been characterized as a function of chopping frequency.

PbS and HgTe quantum dots for SW IR devices
Witold Palosz, Sudhir Trivedi, Brimrose Corp. of America (United States); Gregory Meissner, Kimberley Olver, Eric DeCuir, Priyalal S. Wijewarnasuriya, U.S. Army Research Lab. (United States); Janet Jensen, U.S. Army Edgewood Chemical Biological Ctr. (United States)

Fairly uniform separation of quantum dots in a plane has been achieved as a result of the ligand behavior of the dot chemistry. C-H bonds, and their resonant frequency, provide useful spectral diagnostics. Absorption wavelengths were determined as a function of quantum dot diameter. Results were reported for both PbS and HgTe quantum dots. Fabrication capabilities are impressive and have resulted in the structures that were presented and shown in the proceedings article.

Also relevant to this session is the following poster presentation and accompanying proceedings article

Chalcogenide based rib waveguide for compact on-chip supercontinuum sources in mid-infrared domain
Than Singh Saini, Umesh Kumar Tiwari, and Ravindra Kumar Sinha
The authors describe a compact on-chip supercontinuum source composed of a chalcogenide waveguide structure and possessing a very high nonlinear

coefficient. Generation of broadband supercontinuum radiation in the mid-infrared region appears possible.

Session 7:
Applications I
Session Chairs:
Priyalal Wijewarnasuriya, U.S. Army Research Lab. (United States);
Arvind I. D'Souza, DRS Sensors & Targeting Systems, Inc. (United States)

Innovations in imaging technology and NASA/ESTO investments in technology development *(Invited Paper)*
Sachidananda R. Babu, NASA Goddard Space Flight Ctr. (United States)

The presenter of this invited presentation described NASA remote sensing efforts, including future Landsat follow-on missions. Some detector technologies in particular were mentioned, including PbS with increased carrier mobility. The notion of exploiting commercial capabilities was a theme emphasized in this presentation.

Target detection in sun glint using the improved MWIR polarization technique
Ji Zheng, Huijie Zhao, Yansong Li, Chi Cheng, BeiHang Univ. (China); Xiaofeng Sun, Pengfei Song, Shitao Wang, China Academy of Space Technology (China)

Glint off water surfaces along the viewing direction to objects under observation can be strongly polarized, and approaches for mitigating the glints using polarized imagery were described. In extreme cases of glint, two polarizers are oriented relative to each other by an adjustable angle. Optimal methods for determining this angle were presented on the basis of optimizing object signal to background contrast. Detector saturation in particular is avoided with this approach. The "L_o parameter" (in the context of ModTran, Cox-Munk) plays a role in determining the optimal relative rotation angle between the two polarizers.

Temperature measurements on fast-rotating objects using a thermographic camera with an optomechanical image derotator
Bettina Altmann, Christian Pape, Eduard Reithmeier, Leibniz Univ. Hannover (Germany)

Thermographic imaging of fast rotating objects has always been a challenge due to image blur during the exposure, and the need to register images taken at different azimuthal angles. The optical approach effectively "freezes" the motion of the rotating part so that thermal imagery can be obtained over its surface, accurately registered with its physical geometry. Currently, rotation rate is measured at the rotating source; future plans call for a servo-loop arrangement that will tune the de-rotator rotation rate with feedback from the imagery. Future work includes study of fast-rotating bearings in the presence of lubricants.

Modeling of IR spectra for nerve agent-sorbent binding
Michael R. Papantonakis, Courtney A. Roberts, Andrew Shabaev, Youngchan Kim, R. Andrew McGill, Christopher A. Kendziora, Robert Furstenberg, Samuel G. Lambrakos, U.S. Naval Research Lab. (United States)

Using a surrogate molecule for the nerve agent SiFA4H (the sorbent), and the introduction of a DMMP (sorbent or simulant) to induce a solute-chromic shift in absorption feature wavelength, precise identification of sorbent concentration could be made. The inverse analysis approach presented allows permittivity functions to predict molecule polarizabilities for the simulant plus sorbent vs sorbent-alone. Although initial efforts are in MWIR, the more spectral feature rich LWIR (800 to 1400 wavenumbers) will also be investigated.

Session 8:
Applications II
Session Chairs:
Paul D. LeVan, Air Force Research Lab. (United States);
Arvind I. D'Souza, DRS Sensors & Targeting Systems, Inc. (United States)

NDIR gas sensing using high performance AlInSb mid-infrared LED as light source
Edson G. Camargo, Yuji Goda, Osamu Morohara, Hromi Fujita, Hirotaka Geka, Koichiro Ueno, Yoshihiko Shibata, Naohiro Kuze, Asahi Kasei Microdevices Corp. (Japan)

A newly-developed AlInSb LED, grown via Molecular Beam Epitaxy, results in efficient, low power illumination for use as a background source for trace gas (carbon dioxide) measurements. This embodiment of an indoor CO_2 sensor makes use of an InSb detector operated at room temperature. The wavelength of the LED could be precisely tuned by the Al concentration; it is currently set near 4.3 μm with 6% Al. Sensitivity of ~15 ppm at 1000 ppm CO_2 concentration was attained experimentally.

Development of nanostructured antireflection coatings for infrared technologies and applications
Gopal G. Pethuraja, John W. Zeller, Roger E. Welser, Ashok K. Sood, Magnolia Optical Technologies, Inc. (United States); Pradeep Haldar, Harry Efstathiadis, SUNY Polytechnic Institute (United States); Eric DeCuir, Priyalal Wijewarnasuriya, U.S. Army Research Lab. (United States); Nibir K. Dhar, U.S. Army Night Vision & Electronic Sensors Directorate (United States)

Various approaches for highly efficient anti-reflective coatings were found possible through growth of nano-tubes along preferred directions. The author first summarized the severe reflection losses from bare Ge and ZnSe optical elements. This approach appears suitable for both visible and infrared spectral regions.

Long wavelength infrared (LWIR) AOTF and AOM modulators using Hg_2Br_2 crystals *(Invited Paper)*
Priyanthi Amarasinghe, Joo-Soo Kim, Sudhir Trivedi, Jolanta Soos, Mark Diestler, Feng Jin, Brimrose Technology Corp. (United States); Syed Qadri, U.S. Naval Research Lab. (United States); Neelam Gupta, U.S. Army Research Lab. (United States); Janet Jensen, James O. Jensen, U.S. Army Edgewood Chemical Biological Ctr. (United States)

Predicted improvements for acousto-optic tunable filters (AOTF) for operation in LWIR, made possible through improvements in Hg_2 (Cl_2, Br_2, and I_2) crystal growth, were described. The above were successfully grown, and the wavelength range extends from 0.35 to 40 μm. This should be compared with TeO_2 as SOA, with its wavelength limitations below 5 μm. For Hg_2Cl_2 in particular, diffraction efficiencies of approximately 26% were found near 1.06 μm; very high with respect to state of the art. Future plans include evaluation of the resolving power of the AOTF.

Overview of detector technologies and IRFPA's for various sensor applications *(Invited Paper)*
Siva Sivananthan, Univ. of Illinois at Chicago (United States), EPIR Technologies, Inc. (United States); Christoph H. Grein, Episensors Inc. (United States), Sivananthan Labs. (United States); Fikri Aqariden, EPIR Technologies, Inc. (United States)

The presenter covered a plethora of topics, including "horizontal integration", HgTe colloidal quantum dots, and various detector growth techniques and performance levels. Comparison was made between MBE as used at EPIR with LPE, including a longer Shockley Read Hall lifetime for LPE. But, LPE has much less tailorability (composition with depth as an example), and requires thinning after growth. Prospects for large crystal growth on large silicon substrates were described. These photodiodes achieve dark current performance corresponding to diffusion in the absorber region plus Auger-1 lifetimes.

Thermal sensitivity of the fundamental natural frequency of a resonant MEMS IR detector pixel
Sedat Pala, Kivanc Azgin, Middle East Technical Univ. (Turkey)

The author described the effect of temperature on the natural frequency for the fundamental mode for a resonant MEMS IR bolometer pixel. The resonating plate is supported at its geometric center. Significantly, a closed form solution is found that allows calculation of the natural frequency of the fundamental, as a function of temperature, thereby enabling a measurable bolometric response. The temperature coefficient of frequency response was found to be 1.90Hz/K.