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GUEST EDITORIAL

Infrared Technologies for Defence Systems

Ravinder Pal

Infrared Technology Development Division, Solid State Physics Laboratory, Delhi - 110 054
E-mail: drrpal@gmail.com

Infrared technology has seen phenomenal growth since its inception during World War II. Defence applications have been the main driver of infrared technology development all over the world. Infrared systems have been mainly developed for night vision, all weather surveillance, search and tracking and missile seeker applications. Ever demanding defence system requirements have facilitated considerable investment. Research has been mainly directed towards the product development. Medical applications such as thermographs, transportation applications such as enhanced vision systems for airplanes, helicopters, sea vehicles, and automobiles, law enforcement applications in drug prevention and criminal tracking, managing forest fires and environmental monitoring are some of the spin-offs. Infrared technology has proven to be a force multiplier in war as well as low intensity conflict situation. Intelligent vision sensor development covering visible-infrared spectrum for automated surveillance, change detection, 3D machine vision systems, dynamic particle metrology, missile and ballistic testing/imaging, faster, more precise and more manoeuvrable robotic applications will drive the future research.

Thermal imagers and imaging infrared seekers are predominantly based on cryogenically cooled focal plane arrays operating at 77 K or lower temperatures. Detector-Dewar-Cooler Assembly having a Joule-Thomson cooler and Integrated-Detector-Dewar-Cooler-Assembly with a mini Stirling cooler are the current work horses for thermal imagers and missile seekers respectively. Research effort has been on improving the crystalline quality and uniformity in detector material, engineering superior materials, larger detector array format, finer detector pitch, increased signal processing functions at the focal plane and low size, weight and power (SWaP) and improved reliability of the infrared systems.

An infrared detector is at the core of any infrared system. High performance multi-element infrared detector arrays covering spectral ranges SWIR (1μm - 3μm), MWIR (3μm - 5μm), LWIR (8μm - 14μm) and VLWIR (14μm - 30μm) have been developed. Tunable bandgap material and device architectures have been engineered to make these devices sensitive to two or more spectral ranges for discerning camouflaged targets, range determination and 3D imaging. InSb and HgCdTe based infrared focal plane arrays have dominated the market share for a long time. Though low operation temperature, non-uniformity within an array and low process yield have been a concern. These problems motivated the development of nBn detector architecture raising the operation temperature, reliability and manufacturability. Superior sensitivity and low SWaP of nBn sensors make them suitable for unmanned aerial systems, unmanned ground vehicles and handheld infrared cameras. Quantum well and quantum dots based on III-V material system have also been researched mainly for the space applications. Type-2 superlattice structures (T2SLS) have shown promise particularly in the LW/VLWIR applications. The merits of T2SLS rest on predictions of performance higher than HgCdTe, higher manufacturing yield and lower cost. HgCdTe based electron-avalanche photodiode detectors (e-APD) providing signal amplification in the detector itself have been developed in the last decade for 3D imaging and long range niche applications. Single focal plane array and optics can be used for active cum passive imaging for better alignment of simultaneously acquired active and passive images of a scene. High gain, low excess noise and high gain-bandwidth product have been achieved in HgCdTe e-APD paving the way for 3-D gated imaging and ranging applications.

Fourth generation of infrared focal plane array and imaging system is the current state of art technology. Current infrared systems are driven by artificially created synchronous timing and global control signals that have no relation to the source of the visual information. Information is processed frame-by-frame in conventional systems. Therefore such systems are not capable of actively driving a vision device. Future generation systems will have neuromorphic processing capability at the focal-plane itself just like human retina which is capable of performing complex signal processing in real time. It will be on the lines of eye-brain system capable of performing a number of image processing operations in the z-plane like in-order, logarithmic photon sensing, spatial filtering, temporal filtering, motion sensitivity, edge enhancement, contrast enhancement, data decomposition and neuromorphic processing of data. Future intelligent vision sensors will be driven and controlled by events happening within a scene. This kind of asynchronous events-driven detector, read-out and processing capability will impart autonomy to the sensor. Output will only be produced corresponding to a change in the scene in the form of asynchronous address events. These sensors will generate lesser data volume thus lowering the burden on information processing hardware.

Special issue of *Defence Science Journal* on infrared technology covers some of the exciting developments in the infrared technology. High quality research papers covering detector and CMOS ROIC design, focal plane array fabrication, infrared camera development, space based systems and infrared system applications have been accepted on the basis of an exhaustive review.

I sincerely thank all the contributors for choosing to publish their research findings in this special issue. Review process has made a considerable improvement in the quality of papers. It is my sincere duty to acknowledge the contribution of our learned reviewers. My special gratitude is reserved for Director DESIDOC and his editorial team for facilitating the entire process in bringing out this issue.

GUEST EDITOR

Dr Ravinder Pal received MSc, MTech, and PhD from Indian Institute of Technology, Delhi, India. Currently working as a Scientist 'G' and heading Infrared Technology Development Division at Solid State Physics Laboratory, Delhi. He also served as a Guest Faculty at Microelectronics Research Group at the University of Western Australia during 2000-2001. His interests include : Development of III-V and II-VI based infrared focal plane array (IRFPA).