MUREP Small Business Technology Transfer (M-STTR) Planning Grants

Title: Au-Plasmonic absorber-based microbolometers for uncooled infrared imaging
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SUMMARY: Microbolometers are a class of infrared detector whose resistance changes with temperature. For highly responsive microbolometers, absorption in the sensing layer is the key. Usually the sensing materials used in microbolometer suffer from low absorption. This is true for a-Si and VOx who are two of the most widely used sensing layer materials for microbolometers. Other than low absorption in the 2-5 and 8-12 μm wavelength bands, the microbolometers fabricated from these materials suffer from lower figures of merits because of their low change in resistance with temperature (TCR). This project targets to improve the microbolometer's figures of merits such as responsivity, detectivity and noise equivalent temperature difference by improving the TCR and absorption. The TCR and absorption improvement will be done using Ge-Sn-O based sensing layer and plasmonic metamaterial based absorber respectively. We propose to investigate some of the optical and electrical properties of GeO thin films mixed with Sn to form an alloy of Ge-Sn-O for uncooled infrared detection. Our group had been a pioneer to introduce Ge-Sn-O alloys for microbolometer application and had been recently awarded a patent on this (US Patent Number 10337927, dated 07/02/2019). This alloy showed a room temperature TCR of -3.0%/k which can be increased to -5%/k by varying the atomic composition. The thin films will be deposited by co-sputtering of Sn and Ge targets in the Ar+O environment using a radio frequency sputtering system. Investigations of 1/f-noise, temperature coefficient of resistance, optical bandgap, activation energy, transmittance, absorptance and reflectance with various atomic compositions of Ge-Sn-O thin film alloys. This work will also include design, fabrication and characterization of microbolometers with suitable atomic compositions of Ge-Sn-O thin films. The plasmonic based absorber made of Au thin film microstructure will be designed and integrated with the Ge-Sn-O thin film sensing layer. We expect to increase the microbolometers figures of merits such as responsivity and detectivity by at least two folds through this work.

The investigation will help us to understand the relationship between the atomic compositions in Ge-Sn-O thin film alloys on some of their electrical and optical properties to utilize them in the microbolometer's sensing layer and integrate it with Au-plasmonic absorber. The proposed work will also yield exciting new properties applicable to adaptive sensors, and micro-sensors for NASA's interest. The investigation will help to implement Ge-Sn-O thin films integrated with plasmonic based absorber for their commercial applications in uncooled infrared detection as the thermal imaging technology involving a-Si and VOx sensing layers is mature and came to a saturation point. This work will also help to develop new materials for microbolometer use in long wave (8- 12 μm) and specially, medium wave infrared (2-5 μm) band where NASA does not have a suitable material to use. The proposed research on microbolometers using Ge-Sn-O thin films falls under the Space Technology Mission Directorate (STMD). This work on microbolometers will also help to develop new sensitive thermal imaging systems for future missions. The groundwork laid through this research project will pave the way for new technology developments in infrared imagers that can be applicable to telescopes and earth observing satellites. Future efforts can also lead to the commercialization of the technology and the implementation of it on small satellite constellations, further reducing costs. This work is of particular interest to Earth observing missions that are more and more relying on multispectral IR imaging. The success of this program would pave the way for filter-less systems which would be a major breakthrough in IR imaging systems.