New Concepts for Infrared Sensing and Imaging

Surface Acoustic Wave Infrared Imaging

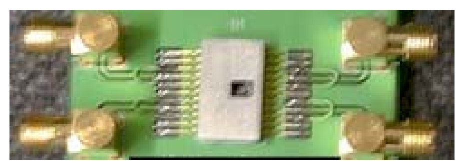
Army Issues and Technology Impact

Infrared (IR) imaging remains a cornerstone technology for many military applications, including small unit operations, ground, air, and sea target acquisition, missile seekers and threat warning systems. However, the cost of present-day high performance cameras can range between $70K and $170K. Besides cost, another disadvantage of these systems is that they typically require to be cryogenically cooled. Therefore, there is a need for the development of more sensitive, uncooled and less costly thermal imaging devices for these as well as other (civilian) applications. The continued need for improved IR imaging systems is evidenced by the statement in June 2001 by Dr. Tony Tether, Director of DARPA, before the subcommittee on Military Research and Development, that "…the program began funding the investigation of new concepts for thermally sensitive microstructures in FY 2000."

The immediate, expected result of this project is a single-pixel, Surface Acoustic Wave (SAW) infrared detector. The long-term goal is to develop an uncooled IR detector camera, based on SAW technology that can be purchased for around $1000. SAW-based imaging technology has not been investigated to any extent. A cheap, uncooled, sensitive IR imaging system based on SAW technology would be a unique instrument and would revolutionize the IR camera market in much the same way as the development of the uncooled microbolometer camera has over the last 5 or more years. Low cost is the key that opens the door to hundreds of markets.

Technical Concept

Our basic concept for the single pixel IR detector is the use of a piezoelectric material that exhibits a high temperature response as a function of some property such as dielectric constant. Our proprietary material exhibits significant permittivity and electro-optic effects at temperatures near the ferroelectric curie point T_c. By adjusting the elemental composition, the paraelectric-to-ferroelectric transition temperature can be varied continuously from 0 K to 435°C.



SAW sensor with IR selective cover removed.

The phase sensitivity to temperature of SAW devices fabricated from this material has been compared with the phase sensitivity of lithium niobate ($LiNbO_3$) SAW devices also fabricated under this project. $LiNbO_3$ was used for this comparison because it is one of the more common SAW device materials that possess a relatively large temperature coefficient of frequency (TFC). The temperature response measurements yielded a resolution of 0.1 °C for $LiNbO_3$, and better than 0.05 °C for the proprietary material. Optimization of fabrication methods will improve this resolution even further.

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ORNL Facilities

ORNL has strong capabilities in sensor development and electronics instrumentation design and testing. The Laboratory also has a Thermophysical Properties Group in the Metals and Ceramics Division who apply IR detectors and imaging cameras to scientific and industrial problems. Thus, IR sensor and imaging devices developed under this project can be tested in-house. Finally, ORNL has strong expertise in piezoelectric and ferroelectric crystalline materials and coatings as well as nanofabrication technologies. This project combines optics, materials research, high-frequency electronics, surface deposition and ion implantation technology, and signal processing, all of which ORNL has significant experience and expertise in.

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