OBJECTIVE: Develop and demonstrate a battery operated ultra-compact long-wave infrared hyperspectral imager (HSI) with monolithically integrated tunable optical filter for detecting targets and threats in cluttered environments.

DESCRIPTION: Recent technological advances have made long wave infrared (LWIR) hyperspectral imaging (HSI) in the 8-12 micrometer wavelength range into a viable technology in many demanding military application areas where materials can be identified by their spectral signatures [Refs 1, 2]. In particular, the operational utility of HSI for detection, recognition and identification of hard-to-detect targets in environments cluttered with background noise is especially critical. Spectral imaging can aid the detection, acquisition and tracking of a potentially camouflaged, low-signature target, such as an unmanned aerial vehicle (UAV) during counter-UAV surveillance, etc., with significantly improved accuracy that cannot otherwise be detected using more conventional imaging means. LWIR spectral range is advantageous for penetrating fog, dust, and aerosols.

Conventional HSI systems [Refs 1, 2] tend to use large, bulky optical elements, such as a Michelson interferometer or other tunable optical filter components to spectrally resolve the input optical signals, and therefore usually have the characteristics of significant size, weight, and power (SWaP) consumption, mechanical complexity, as well as non-compliance with military specifications. Furthermore, the mechanical mechanism of the conventional tunable filtering system gives rise to slow spectral speed and thus, slow imaging speed. As a result, conventional HSI systems do not lend themselves to the field applications that require handheld portability and faster response times.

The goal of this effort is to develop a compact, LWIR HSI system based upon the monolithic integration of a tunable optical filter with a large-format LWIR focal plane array (FPA). The FPA should be based on either II-VI Mercury Cadmium Telluride materials, or III-V strained layer super lattice (SLS) structures. The tunable optical element can be a micro-electro-mechanical systems (MEMS)-based tunable Fabry-Perot filter or other hyperspectral tunable filter monolithically integrated with the FPA. The development effort also needs to include the necessary read-out and programmable electronics integrated with the monolithic FPA and tunable filter ensemble to enable real time spectral image processing.

System required parameters include:
1. Tunable wavelength range: 8-12 microns
2. Array size: at least 320 x 256 pixels
3. Pixel pitch: 12 microns or less
4. Tunable filter peak transmission: >55%
5. Tunable filter full-width at half-maximum: 500 nm or less
6. Tunable filter out-of-band rejection: > 15:1
7. Pixel-to-pixel wavelength variation across the FPA: < 4%
8. System weight with batteries: < 6 pounds
9. System size < 60 cubic inches

PHASE I: Design, develop, and demonstrate a compact LWIR HSI with monolithically integrated tunable optical filter to meet specifications identified in the Description. Analyze and model to identify the performance and limitation of proposed technologies. Identify any additional optics and electronics required for the HSI system configuration and operation. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Optimize the designs from Phase I. Provide updated analysis and models for any design improvement. Fabricate and characterize a system prototype to meet design specifications. Demonstrate prototype and provide an operating manual for laboratory and field-testing.

PHASE III DUAL-USE APPLICATIONS: Fully develop and transition the compact hyperspectral imager with monolithic tunable optical filter based on the final design for Naval applications in the areas of target detection, recognition, and identification.

The commercial sector can also benefit from this compact hyperspectral imager with fast response time in the areas of detection of toxic gases, environmental monitoring, and noninvasive health monitoring and sensing.

REFERENCES:


KEYWORDS: Hyperspectral Imager; Target Detection; Target Identification; Target Recognition; Long-Wave Infrared; Tunable Filter