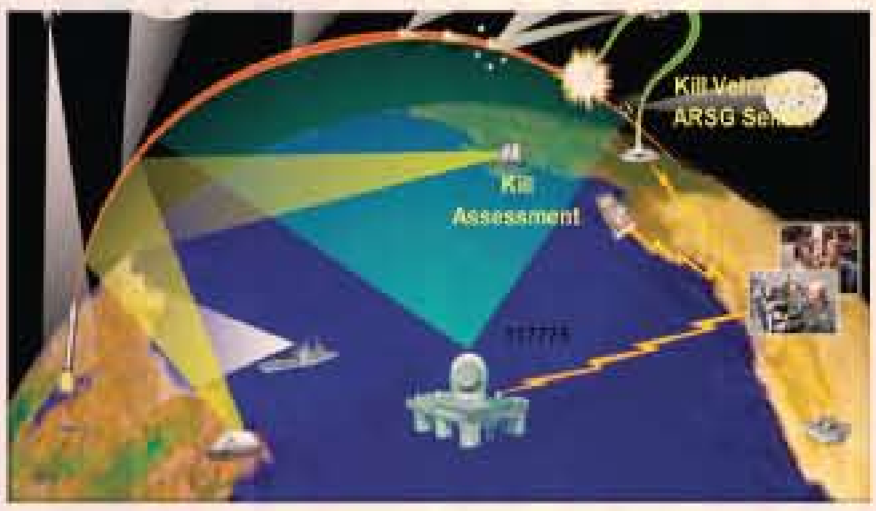
High-Speed Spectral Sensor

LABORATORY DIRECTED RESEARCH & DEVELOPMENT

Sandia National Laboratories
PI: Shanalyn Kemme/Aaron Gin, PM: Lee Marshall

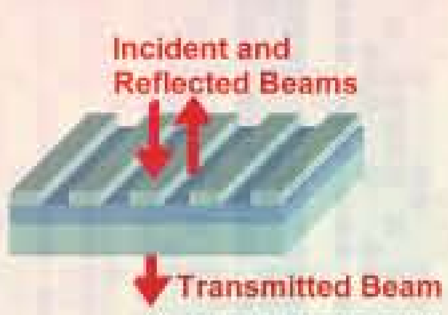
Motivation



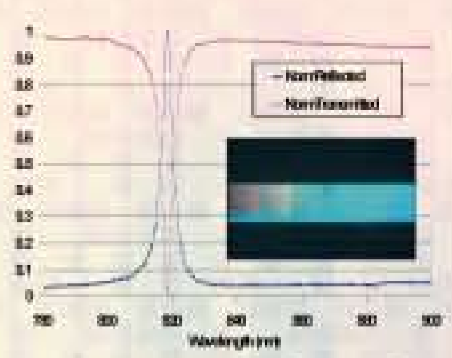
- Kill Assessment (KA) from a hyper-velocity exo-atmospheric missile intercept requires high-speed, low-mass, small, robust, spectral sensing systems not available as commercial products.
- It would be useful to create a fast, wavelength-agile filter that could augment conventional focal plane array capabilities.

Problem

- Develop a multi-color spectrometer and radiometer based on an active resonant subwavelength gratings (RSG) as the high-speed tunable optical filter. Integrated sensor will be small and lightweight enough to use the KV as its platform.
- Previous LDRD work has shown impressive results in passive resonant subwavelength gratings[1].
- We will extend the technology by realizing active devices that are wavelength-agile and can operate at high speed.



Passive RSG Schematic

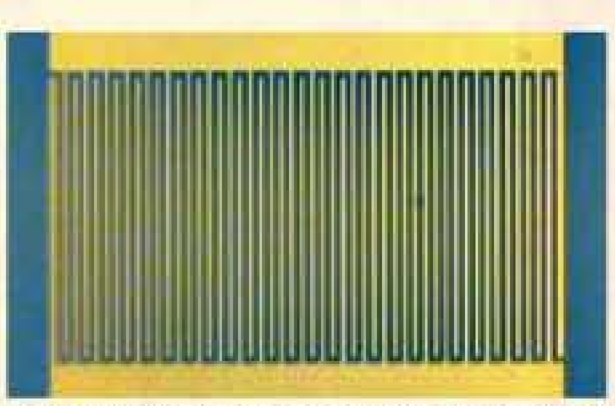


Measured resonant reflection and transmission curves for passive RSG device

1. Shanalyn A. Kemme, David W. Peters, Joel R. Wendt, Tony R. Carter, Sally Samora, G. Ronald Hadley, Mial E. Warren and Carter L. Grotbeck, "Arrayed Resonant Subwavelength Gratings LDRD 38618 Final Report", SAND Report 2003-4111 (2003).

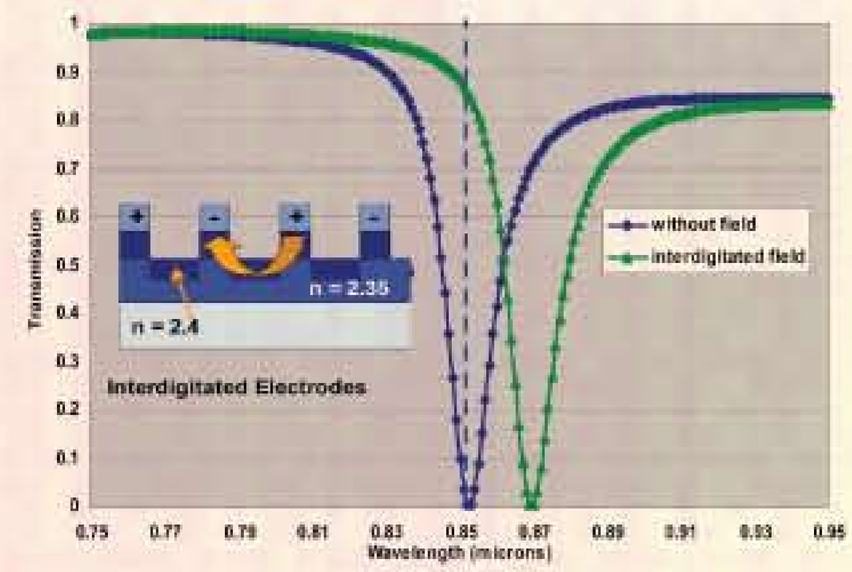
Approach

- An active RSG micro-optical system that can be geometrically scaled to access a wide wavelength range and accommodate a set of phenomenologies from initial fireball flash analysis (UV-SWIR) to debris cloud evolution (out to LWIR)
- Interdigitated electrode arrays to modulate an electric field within a thin film of electro-optic material such as PLZT or $BaTiO_3$.
- Modulation of this field modifies the refractive index of the thin film and shifts the resonant reflection peak and transmission dip.



SEM of Active RSG

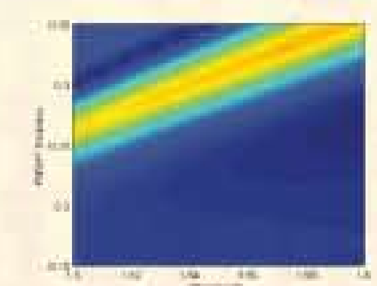
10µm gold grating on PLZT, Device size 500x400 µm



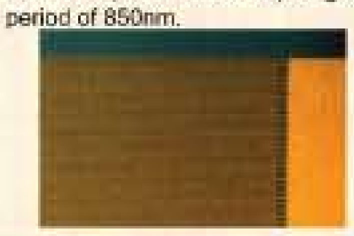
Interdigitated electrode configuration to achieve a field strength of $3X10^7$ V/m. This translates to an increase in the refractive index of 0.05 with 40-V bias potential for 90% contrast.

Results

- We have identified three candidate materials for use in the active RSG devices: PLZT, PMN-PT and $BaTiO_3$.
- RCWA modeling has been used to predict the behavior of devices with various materials, electrode geometries, and field strengths, etc.
- In-house material synthesis has been successful.
- Initial device processing has been performed on all three material systems.
- Laboratory experiments are now underway to verify theoretical models.



Difference in the transmitted power as a function of wavelength and PMN-PT thickness (both in microns) for grating period of 850nm.



Active RSG interdigitated electrode structure formed with Ti/Au metal on $BaTiO_3$ thin film on c-sapphire substrate.

Significance

- Resonant subwavelength grating (RSG) devices can be scaled to access a range of wavelengths from UV to LWIR.
- Active RSGs are inherently fast (low C) and have no moving parts.
- Active RSG will be small, lightweight, rugged, and dissipate little power.
- These high-speed optical filter arrays may ultimately enable fast spectrometry for various space applications, such as kill assessment.
- This project demonstrates SNL capability in synthesis of electro-optic materials, device fabrication and characterization, as well as system integration and testing.

Team Members

Shanalyn Kemme	01725	Coordinate design, fab, characterization
Aaron Gin	01725	Coordinate fab, characterization
Walt Zubrzycki	05719	Electronics design and build
Paul Clem	01824	Materials synthesis
Rob Boye	01725	Optical design
David Peters	01727	Optical modeling
Tony Carter	01725	Experimental device testing
Sally Samora	01725	Device fabrication

Contact:
Aaron Gin, 01725, Photonic Microsystem Technologies
284-1260, agin@sandia.gov

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