Nanoantenna-Enabled Midwave Infrared Detection

David W. Peters, Darin Leonhardt, Charles Reinke, Jin K. Kim, Paul Davids, Joel Wendt, John Klem

dwpeter@sandia.gov

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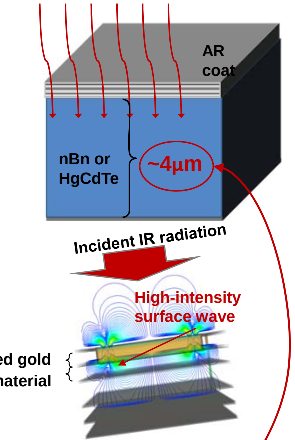
Concept

In a traditional pixel the active layer must be thick enough to absorb the incoming radiation.

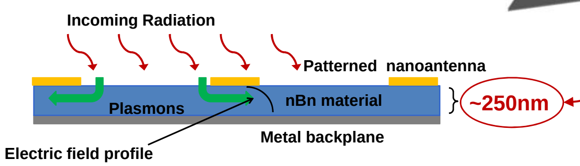
The nanoantenna converts plane waves to highly concentrated surface waves.

This allows the active layer to be made much thinner than in the traditional pixel architecture.

Traditional MWIR FPA Pixel



Nanoantenna-Enabled MWIR FPA Pixel



Over an order of magnitude reduction in active material

Advantages for near-IR, MWIR, and LWIR Focal Plane Arrays → Performance Improvements and Design Flexibility Independent of Active Material

What does thin buy you?

Volume of active material (MCT or nBn) required goes down by over an order of magnitude.

Less material → lower dark current → better performance at a fixed temperature or equal performance at a higher temperature (less cooling required).

Thin layer allows more freedom with strain of the material. In the case of nBn, we can push the cutoff wavelength higher by tenths of microns.

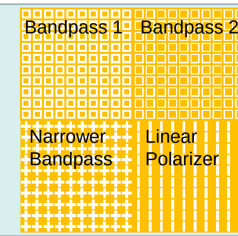
Thinner layer means less dead area between pixels used for reduction of crosstalk, and leading to better modulation transfer function (MTF) → higher resolution.

Less material deposition = easier fab/higher yield/fewer dead pixels. Should lead to lower cost detectors.

Incorporate optical features at pixel level:

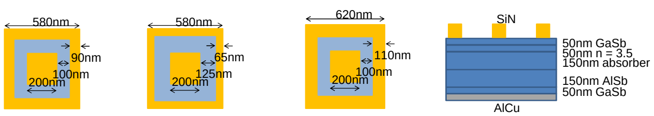
We have made bandpass filtering and polarizing nanoantennas → we can integrate filtering functionality on the detector itself.

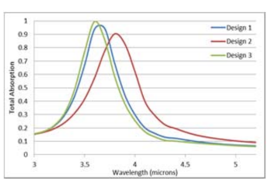
Our active material is broadband, allowing two-color FPAs. AR coat may be changed pixel to pixel.

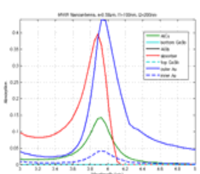


Optical Modeling

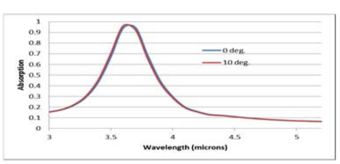
Shows where the absorption occurs.
Optimize designs for largest absorption in active region.
RCWA, FDTD, and FEM modeling.





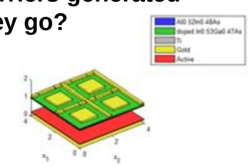


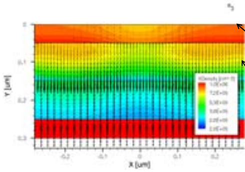
Nanoantenna spectral band is usually independent of angle.



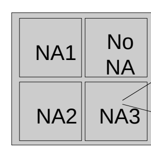
Electrical Modeling

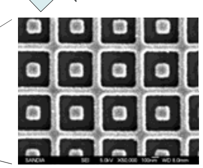
Where are the carriers generated and where do they go?





The three nanoantenna designs are patterned on the same stack plus a no nanoantenna control.



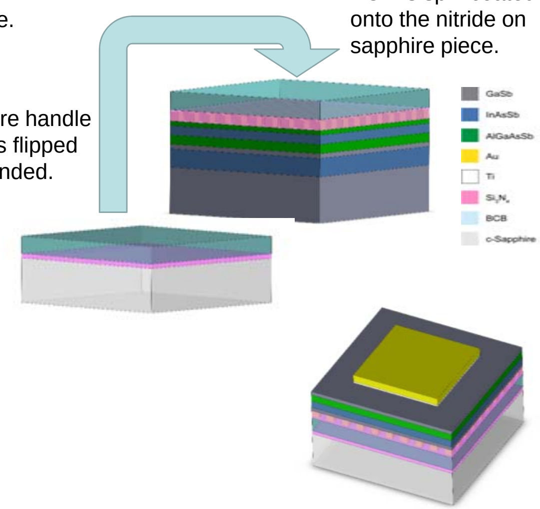


Fabrication

- Epitaxial layers are grown on GaSb.
- Nanoantenna is fabbed using metal liftoff process.
- Wafer is bonded to a sapphire handle wafer and the GaSb removed.
- Detector connections made.

BCB is spin coated onto the nitride on sapphire piece.

Sapphire handle wafer is flipped and bonded.



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