National Aeronautics and Space Administration

FY24 R&TD Innovative Spontaneous Concepts (ISC)

Miniaturized and rugged infrared multispectral sensor for small planetary platforms

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Strategic Focus Area: Innovative Spontaneous Concepts

How?

We have chosen to fabricate **periodic metallic arrays of holes** using aluminum (Figure 2b), which can serve as **plasmonic filters** in Mid-Wavelength infrared (MWIR) range. Our approach involves integrating these nanohole filters onto the surface of high-performance InAs/InAsSb barrier **infrared photodetectors**.

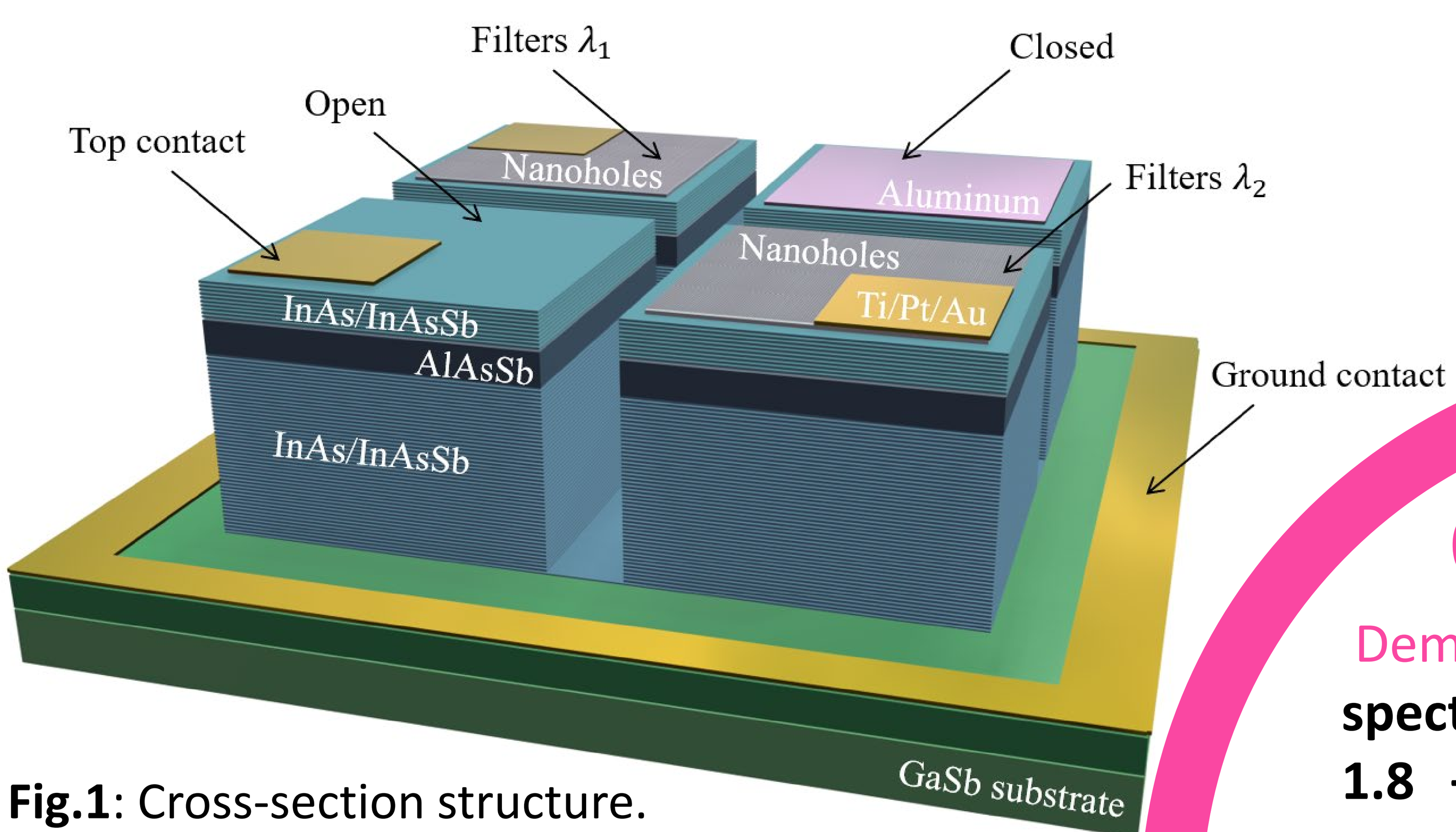

Fig.1: Cross-section structure.

Fabrication

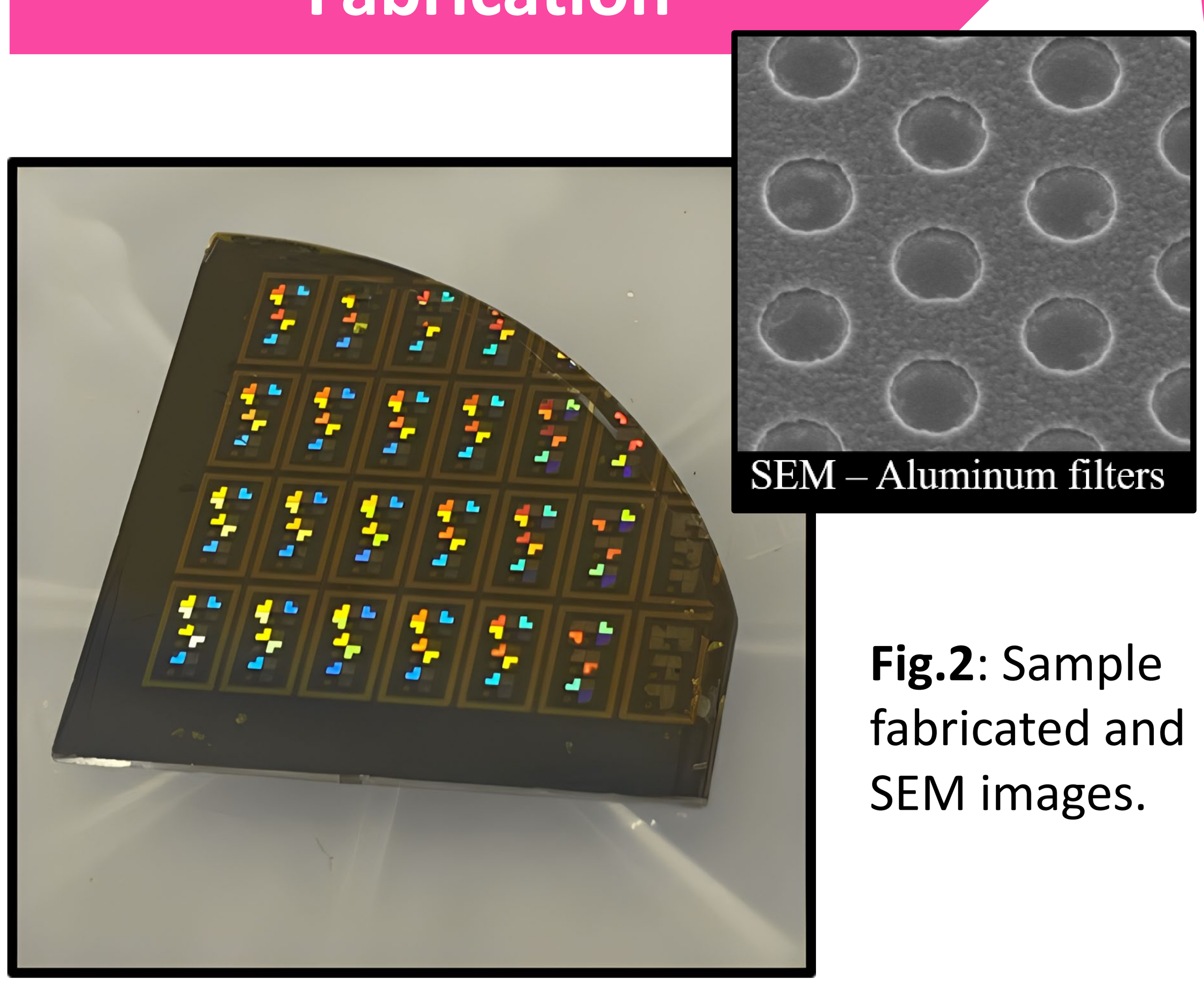

Fig.2: Sample fabricated and SEM images.

Simulations

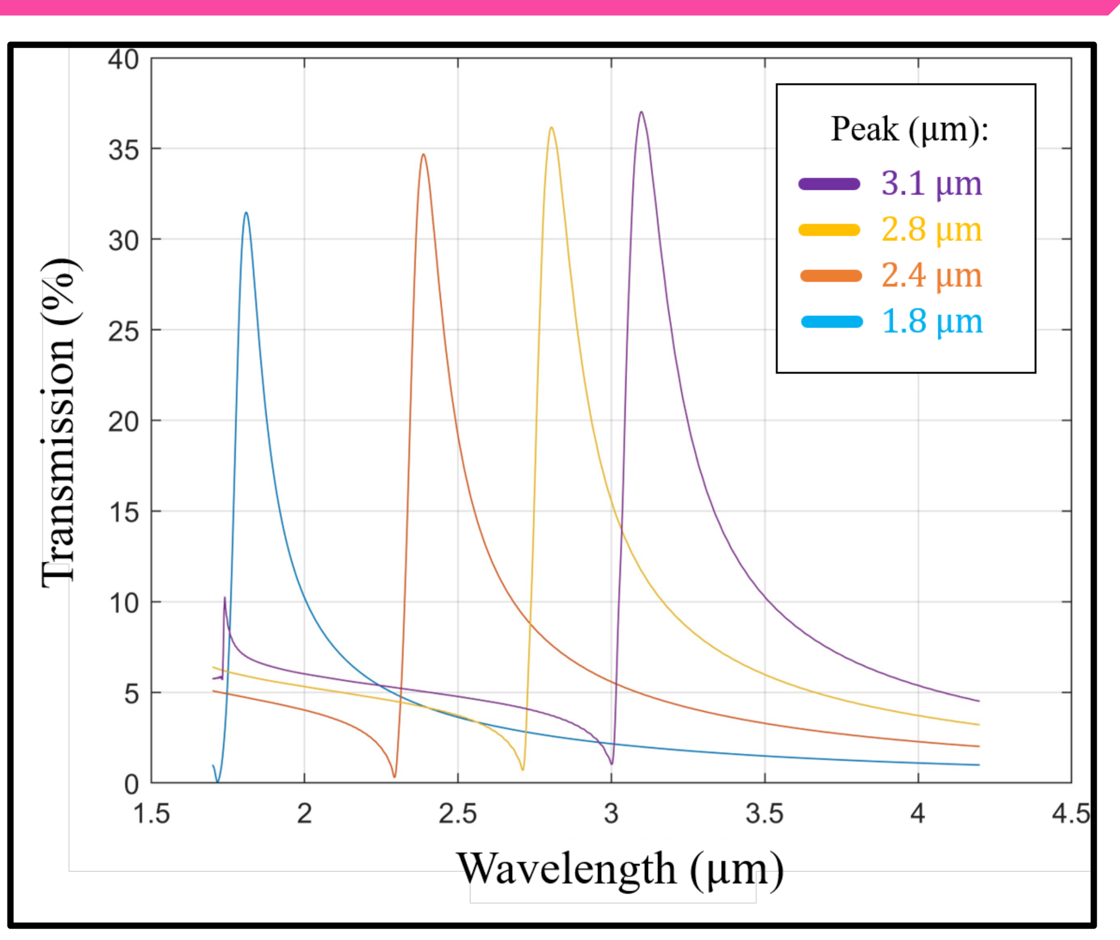

Fig.3: Filters transmission simulated.

Why?

Despite a well-known need for spectrometers on chip, it is extremely difficult to build one capable of providing a **high spectral resolution** and **broad spectral coverage**.

- However, for many applications the goal is less emphasis on a high-resolution spectrum, but on dependent characterization and identification of the materials based on spectral properties of the reflected light.
- Multiple chemical elements of interest have their fingerprint in **short and mid-wavelength infrared** (SWIR and MWIR): e. g. H2O, clays, hydrated silica, Al-bearing clays, hydrated silica, gypsum.
- Sensors onboarded on Mars exploration helicopters or surface penetrators need optimization of **SWaP parameters** (Size, Weight and Power) required an important **work on the electronics**.

Objectives:

Demonstration of a **multi-spectral sensor** operating in **1.8 – 2.6 µm** band with a spectral resolution of **100 nm**, evaluation of its performance for detection of selected mineral and **design of the electronics** to ensure a time-phased, low-power consumption, digital output.

Benefits to JPL & NASA

Our proposed solution is significantly **smaller** than current NASA instruments and fits on a detector chip. Our solution targets a need for spectral sensors with **small footprint**, **lower power consumption** and **light weight** that can be carried by a small rover, helicopter or astronaut. Such sensors, a particularly next generation covering water absorption band near 3 µm, are critically needed to support NASA's vision, of prospecting **the Moon and Mars**, and expanding future space exploration.

Main Results

- **Simulation & Design**: filters transmission simulation were carried out with Lumerical FDTD software to define the design (**period and diameter**) of the **nanohole** arrays for covering **SWIR** spectral range.

- **Development of the fabrication process**: as to our knowledge, the integration of aluminum nanohole filters with high-performance MWIR photodetector has never been demonstrated in the literature and represented an **important technological challenge**.
  - The **process of fabrication** has been developed step-by-step.
  - We studied the impact of the **e-beam photolithography** parameters on the resolution and geometry of the nanoholes.
  - We developed and optimized a **dry-etching** chlorine-based recipe allowing a well-control of the shape, rugosity, and depth of the nanoholes.

- **Fabrication of a first sensor**: We recently finalized the process of **the first demonstration sample** of the aluminum filters. The intense colors observed in the picture prove the great quality of the surface.

- **Mounting and characterizations:** this sample has been mounted on a chip carrier, wire-bonded, and spectral response measurements have been performed. **The first measurements** are currently being analyzed and will need **further investigation**.

- **Future works:** In parallel, we are developing larger arrays of nanohole patterns to conduct **transmission measurements** on our filters. This will allow us to compare the consistency of the **experimental** results with the **simulation** of the transmission.

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