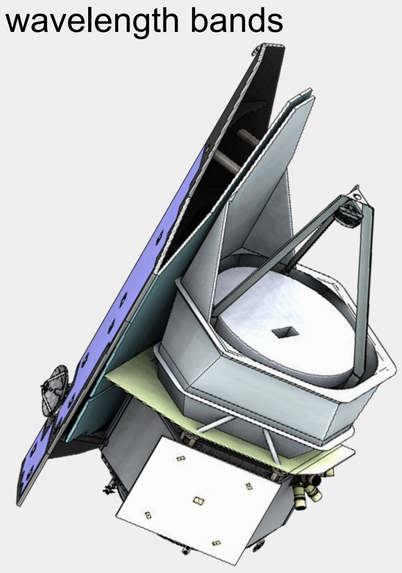
Parallel Plate Capacitor Aluminum KIDs for Future Far-Infrared Space-Based Observatories

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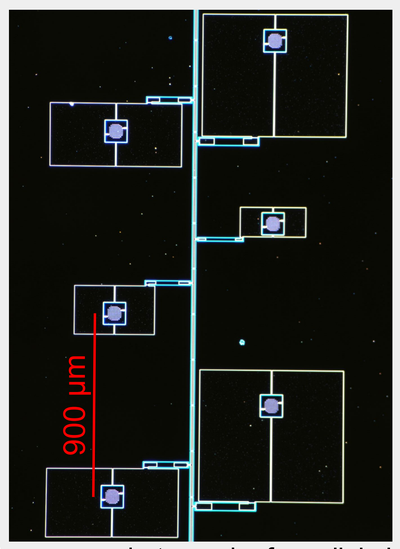
The PRobe far-Infrared Mission for Astrophysics

- The PRobe far-Infrared Mission for Astrophysics (PRIMA)
  - Bridging wavelength gap between ALMA and JWST
  - Observations of AGN feedback, interstellar medium physics in galaxies
  - Growth over cosmic time of stars, black holes, heavy elements, dust
- Telescope and observing bands
  - 2 meter, 4.5 Kelvin primary mirror
  - Spectrometer and imager modules
  - Short (24 – 75 μm) and long (75 – 235 μm) wavelength bands
- Short wavelength band spectrometer detectors
  - Kinetic Inductance Detectors (KIDs) [1,2,3]
  - Low-volume aluminum resonant absorber
  - Many kilopixel KID arrays

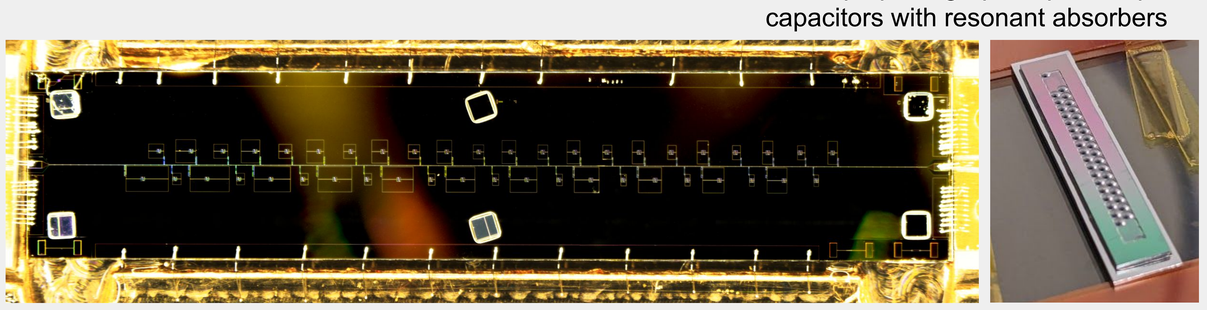


Aluminum Parallel Plate Capacitor Kinetic Inductance Detectors

- Short wavelength band spectrometer KIDs
- Parallel plate capacitors
  - a-Si:H dielectric, Al and Nb electrodes
  - Small footprint, reduces EM crosstalk
- Aluminum absorber
  - Resonant absorption efficiency
  - Niobium quasiparticle plugs
- Prototype kilopixel arrays with high yield
- Monolithic silicon microlens arrays [4]
  - Antireflection coated
  - Efficient optical coupling



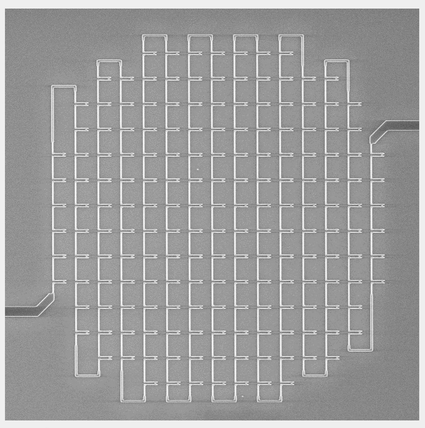
Microscope photograph of parallel plate capacitors with resonant absorbers



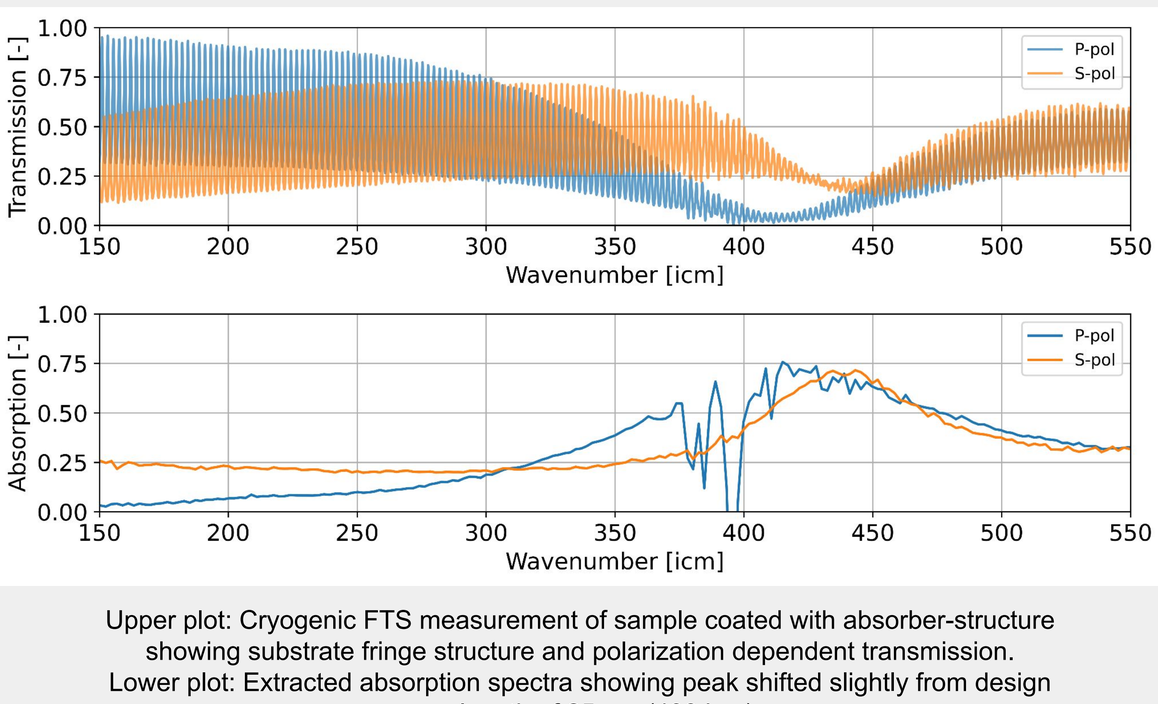
Left: microscope photograph of 44-pixel 900 μm pitch prototype 25 μm wavelength array.
Right: 44-pixel 900 μm pitch microlens-detector hybridized array

Resonant Absorber Coupled Detectors for λ ~ 25 μm

- Dual polarization resonant absorber structure
  - Hairpin-style meandered path
  - 70 μm absorber diameter
  - Increase in-band absorption
  - Simulate geometry in HFSS
- First iteration absorption measurement
  - Pattern design across wafer
  - Fourier Transform Spectroscopy (FTS)
  - Absorption extracted from fringe pattern
  - Found absorption peak near design
- Currently optimizing absorber geometry
  - Shift peak to desired center wavelength
- Comparisons to shot noise indicate expected optical efficiency



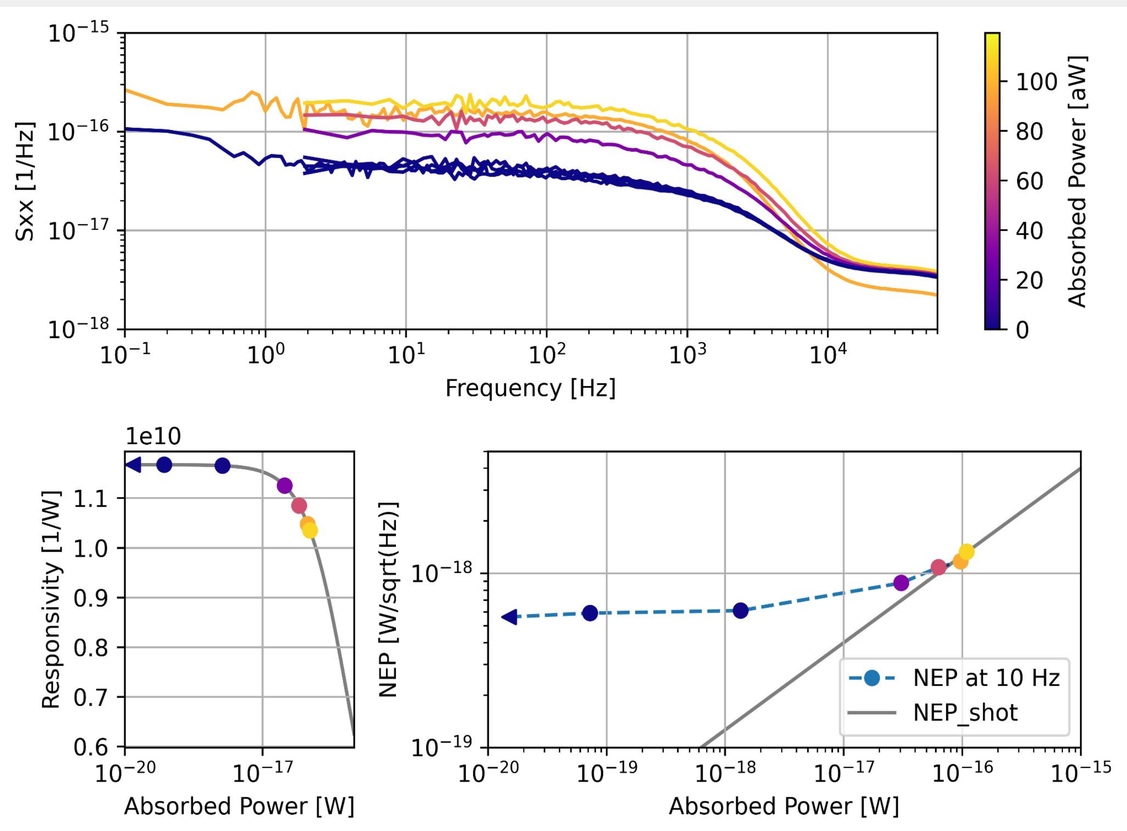
Scanning electron microscope image of aluminum hair-pin style resonant absorber



Upper plot: Cryogenic FTS measurement of sample coated with absorber-structure showing substrate fringe structure and polarization dependent transmission.
Lower plot: Extracted absorption spectra showing peak shifted slightly from design wavelength of 25 μm (400 icm).

Responsivity and NEP Measurements

- 44-pixel short wavelength spectrometer band prototype array
  - Very high yield (43/44) with typical frequencies 250 – 1400 MHz
  - See Logan Foote's poster (TP-029) for TLS details [5]
  - See Elijah Kain's poster (TP-033) for time constants [6]
    - Measured responsivity agrees with measured lifetimes and volume
  - Optical measurements show efficiency working as expected
    - NEP ~ 5.5 x 10^{-19} W/rt(Hz)
  - Lower NEP expected:
    - With upcoming devices with longer recombination times
    - After cryostat stray light improvements



Upper plot: Fractional frequency shift noise spectra of one detector as a function of absorbed power.
Lower left: Responsivity measurements and fit. Lower right: Optical NEP measurement at 10 Hz.

Conclusions and Next Steps

- Demonstrated PRIMA short wavelength band spectrometer KIDs
  - Successful parallel plate capacitor geometry
  - Successful resonant absorber design
  - Successful high-yield kilopixel prototype arrays
  - Successful microlens optical coupling of small-format arrays
  - NEPs near PRIMA target
- Next steps:
  - Improve NEP via absorber design iteration and cryostat improvement
  - Characterize crosstalk for parallel plate capacitor KIDs
  - Demonstrate kilo-pixel array performance

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