National Aeronautics and Space Administration

FY23 Strategic Initiatives Research and Technology Development (SRTD)

Thermal Kinetic Inductance Detectors for far-IR Astrophysics

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Strategic Focus Area: Long-Wavelength Detectors **| Strategic Initiative Leader:** Charles Lawrence

Objectives:

1. prepare our antenna coupled TKIDs for a field demonstration in a ground based Cosmic Microwave Background experiment (BICEP)
2. to explore means of operating the detectors with background limited performance at lower loading levels.

Background:

- Future long wavelength satellites require 10^4-10^5 element focal planes of rad hardened background noise limited detectors (<10^{-18} w/rtHz). KIDs and TESes are traditional choices for these instruments.
- TESes are mature, but difficult to integrate with their SQUID readout.
- KIDs have matured in recent years, but demand challenging fabrication and cosmic rays can be a challenge.

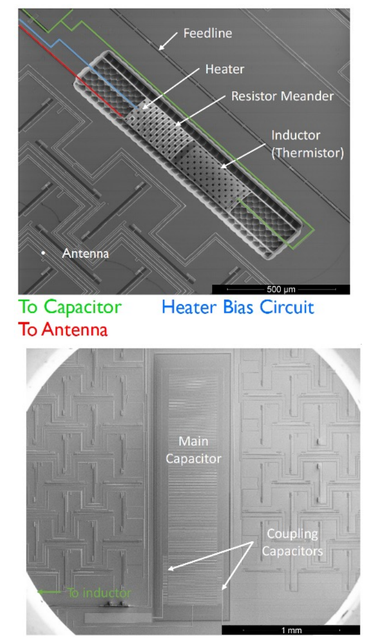

Fig 1: SEMs of Antenna coupled TKIDs

Approach and Results:

- TKIDs are drop in replacements for TESes, with resonator inductors functioning as island thermometers (Fig. 1)
- Optical coupling and fundamental noise offer design flexibility. Released islands offer natural Cosmic Ray immunity.
- We use cryogenic VNA measurements and the laser-writer lithography tool (MLA) mid-fabrication to identify and fix errors that would render low yield tiles (Fig 2).
- We are exploring Tungsten Silicide (WSi), working with the SNSPD team, as a high resistivity low-Tc material for TKID inductors (Fig 3), useful for lower loading applications.

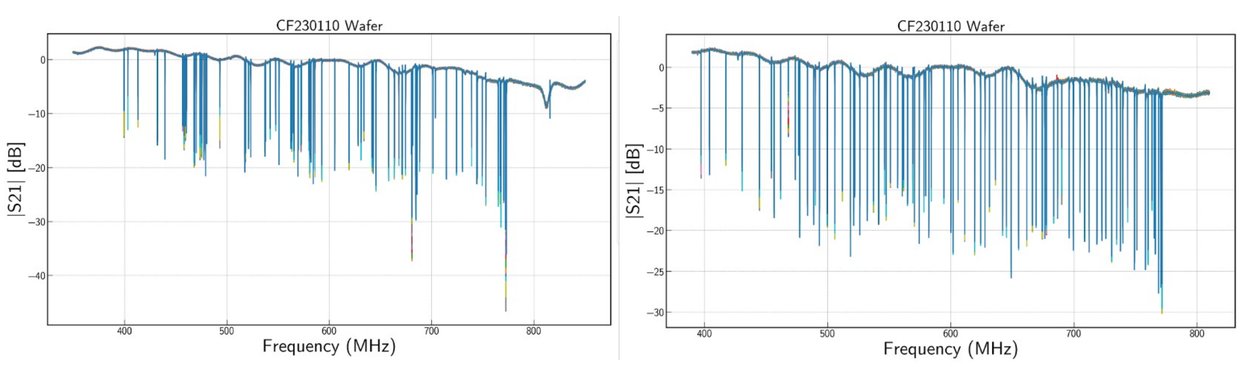

Fig 2: before (left) and after (right) trimming and adjustments to defects in a TKID array. These tricks have helped us prepare high yield tiles for deployment in a BICEP field tests

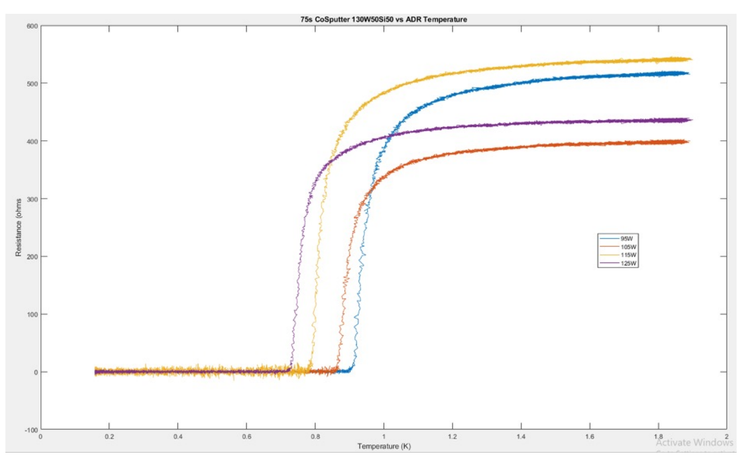

Fig 3: WSi transitions with different doping levels allow us to control the Tc. We adjust W content by co-sputter from two targets. This is under development for both SNSPDs and TKIDs

Significance/Benefits to JPL and NASA:

- Results provide a pathway to maturing and lower noise in TKIDs, for use in future long wavelength space telescopes.
- Caltech is moving CSO to Chile's Atacama Desert, rechristened Chajnantor Leighton Telescope. TKIDs are a technology under consideration for use there for intensity mapping.

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Publications:

Wandui, A., et al. "Thermal Kinetic Inductance Detectors for millimeter wave detection," Journal of Applied Physics, 128, 044508
Wandui, A. et al. "Antenna-coupled thermal kinetic inductance detectors for ground-based millimter-wave cosmology." SPIE 114531

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