Fabrication of antenna coupled transition edge sensors for polarimeter applications

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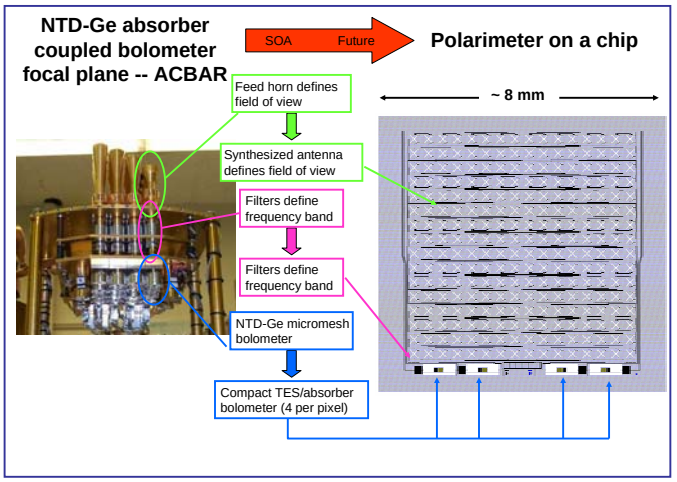
Abstract

In this poster we describe progress in the development polarization sensitive superconducting, bolometric detector arrays targeted at Cosmic Microwave Background (CMB) studies. Our implementation takes advantage of superconducting technology to reduce the complexity of the typical CMB bolometer focal plane by incorporating as many of the required elements on the detector itself. Each pixel in the array consists of a distributed dual-polarization beam forming antenna, a band pass filter, and power splitter/combiner delivering detected power to four separate superconducting transition edge sensors (TES). This combination of elements detects the polarization of the incoming light uniquely while eliminating a large part of the cooled mass of the focal plane including feed horns, polarizers , and band pass filters. Of course this increases the fabrication complexity of the bolometric detector itself over previous implementations. We will describe our fabrication process consisting of eight front side mask levels and one back side layer designed to produce whole wafer array tiles suitable for CMB polarimeters.

Comparing Detector Architectures

	NTD-Ge/Absorber Coupled	Polarimeter-on-a-chip/ Antenna Coupled
Coupling	**Metal feedhorn** •Well defined field of view. •Mature technology. •Large mass and volume (limited array scaling and large cooling requirements.	**Dual polarization beam forming antenna** •Polarization sensitive – (one or both polarizations with bandwidth trade-off) •Limits field of view on chip. •Easily integrated with other detector types. •More complex pixel to fabricate.
Band definition	**Macroscopic filter elements.** •Mature technology •Large mass and volume	**Superconducting lumped element filters.** •Integrated on chip. •Potential for multi-color. •Less mature.
Bolometer	**NTD-Ge with micromesh absorber.** •Excellent noise performance (low 1/f). •Mature technology. •Large area thermally isolated structure (fragile)	**TES with resistive absorber** •Compact thin film detector (easily integrated into large arrays) •Detector noise not as good (more 1/f than desired).
Readout	**JFET** •Mature technology. •Not yet multiplexed (limit to scalability)	**SQUID** •Multiplexable. •Operates at or near detector temp. •Low noise. •Not fully developed.
Other features		•All four Stokes parameters measured with on chip hybrid coupler. •Potential for polarization switching on chip.



Process Flow

Process features:

•Nine mask level process – 8 frontside , one backside.

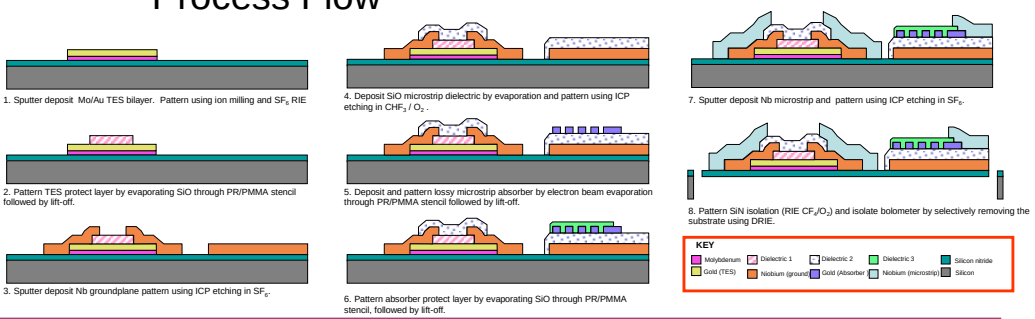
•All front side lithography 5x projection/step and repeat (Canon FPA3000 –EX3).

•Low rf-loss Niobium/SiO/Niobium microstrip.

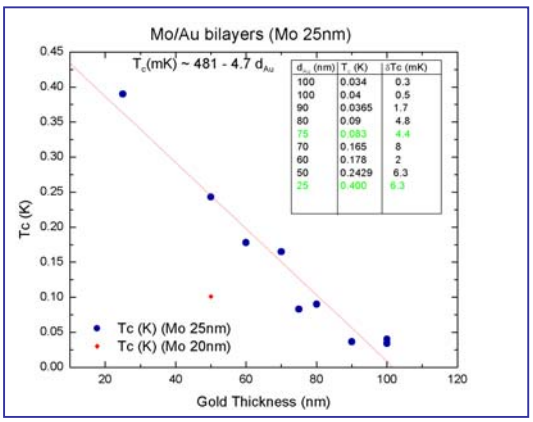
•Lossy Gold microstrip absorber.

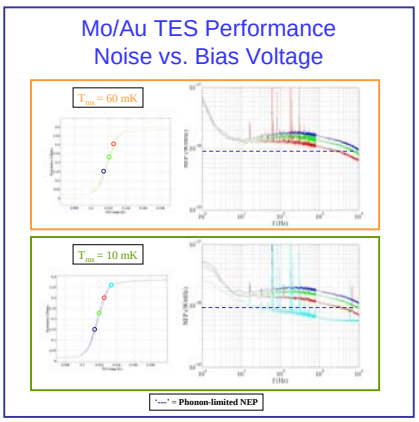
•Molybdenum/Gold transition edge sensor.

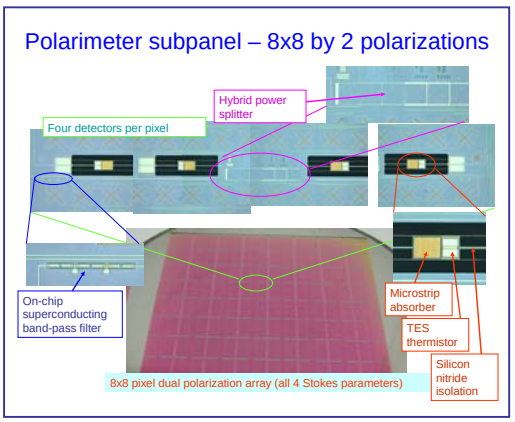
•Seamless wire stitching to bring all 512 detector leads to edge of die ~80mm square die.



Progress in Process Development







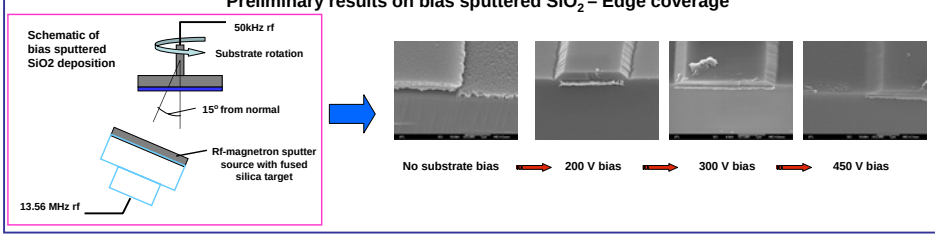
Future Development

•Replace evaporated SiO dielectric layers with bias sputtered SiO_2.

•Replace lift-off processes with etch processes.

•Improve TES TC targeting and reproducibility.

•Improve yield.

•Scale-up to 150 mm wafers.

Preliminary results on bias sputtered SiO_2 – Edge coverage