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Kilopixel-Scale Arrays of Kinetic Inductance Detectors on 150 mm Diameter Substrates for the TolTEC Millimeter-Wave Polarimeter

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Kinetic Inductance Detectors (KIDs) carry the promise of a truly scalable detector solution, capable of filling the ambitiously large and densely populated focal planes envisioned for future sub-millimeter and millimeter-wave instruments. As part of our effort to realize their full potential, we have developed and fabricated the first kilopixel-scale arrays of KIDs on 150 mm diameter silicon on insulator (SOI) substrates. These initial arrays are being produced for TolTEC – a new millimeter-wave imaging polarimeter being constructed for the 50-meter Large Millimeter Telescope (LMT). TolTEC uses dichroic filters to define three physically independent focal planes for observations at bands centered at 1.1, 1.4, and 2.0 mm. Each focal plane is filled by a single monolithic detector array fabricated on a 150 mm diameter wafer, and together the three arrays comprise 7,000 polarization sensitive KIDs. Every spatial pixel consists of two detectors, each sensitive to two orthogonal linear polarizations. These devices use a combination of TiN/Ti/TiN multilayer films and thick aluminum films to engineer optimal performance tuned to the loading and observing conditions expected for each band of TolTEC. Here we review the lumped element resonator design, detector optimization, and optical coupling scheme. Furthermore, we describe the integration and layout of thousands of these devices into individual large-scale arrays, which are read out with multiplexing factors of 500–700. We illustrate the design and integration of an entire focal plane module including the micromachined silicon-platelet feedhorns and optical coupling components, the microwave readout interface, and the thermomechanical design. We present the latest laboratory measurements and characterization of these full-sized detector arrays, including the fully-realized 2,000 pixel (4,000 detector) 1.1mm band module, and compare their measured performance to that predicted by theoretical models and simulations.

Less than 5 years of experience since completion of Ph.D

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