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Towards Photon Counting Kinetic Inductance Detectors for Far-Infrared Spectroscopy

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Photon-counting detectors are an enabling technology for future space-based far-infrared spectroscopic instruments such as those proposed as part of the Origins Space Telescope (OST) and would greatly increase the sensitivity and mapping speed of potential instruments. Microwave kinetic inductance detectors (KID) are a promising technology for these instruments, where large arrays of detectors with noise equivalent powers (NEP) less than $3 \cdot 10^{-20}$ W·Hz$^{-1/2}$ will be required to achieve photon-noise background limited performance. In contrast to superconducting transition edge sensors (TES), KIDs are naturally frequency multiplexed allowing for the simple readout of large arrays, but a factor of nearly ten improvement in NEP is needed to meet the needs of future space-based spectrometers. Our project seeks to develop KID technology and achieve NEPs suitable for future space missions through the use of a novel lumped element KID design with optical coupling implemented at 850GHz. Utlizing ultra-low volume Al inductors to increase responsivity and photonically choked NbTiN parallel plate capacitors on single crystal silicon to minimize interface defect-driven two-level system (TLS) noise, our design seeks to approach the photon counting limit, where detector baseline calibration is obviated and full duty-cycle observation can be achieved. We are currently studying both NbTiN and Al deposition parameters to achieve films with low TLS densities and high internal quality factors, while simultaneously developing low-defect compatible fabrication processes and an ultra-low background measurement facility with an integrated cryogenic blackbody calibrator to charaterize our high sensitivity devices.

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