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Improving tunnel junction yield in arrays of CMB TESs cooled by NIS refrigerators

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Refrigerators based on normal metal-insulator-superconductor (NIS) junctions are an attractive solution for cooling superconducting detectors, particularly in balloon- and space-based experiments. The addition of NIS devices to a cryogenic system can enable payload temperatures near 100 mK from launch temperatures near 300 mK. Used in conjunction with a ^3He sorption fridge, NIS devices can provide a simple, compact, and reliable cooling chain. Lowering the operating temperature into the 100 mK regime allows for detector designs with lower noise equivalent power (NEP) and higher mechanical robustness compared with many detectors used in past balloon-born experiments. We are presently developing arrays of NIS-cooled transition-edge sensor (TES) bolometers for cosmic microwave background (CMB) science. Each TES in the array relies on cooling from eight NIS junctions, and therefore high junction yield is of critical importance. We present recent work on increasing the fabrication yield of NIS-cooled TES devices by reducing the surface roughness of the SiN-on-Si substrate. Using our in-house grown SiN, we have substantially improved the substrate surface roughness from $\text{RMS} = 0.75 \text{ nm}$ to $\text{RMS} < 0.4 \text{ nm}$, resulting in fewer shorts in the nm-thick tunnel barriers. Si-rich regions are likely the cause of unwanted roughness peaks in previously-used SiN-on-Si substrates. We demonstrate successful NIS refrigeration of TESs similar to those used on the most-recent camera installed on SPIDER, a balloon-born CMB experiment.

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

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Student (Ph.D., M.Sc. or B.Sc.)

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