V256a Development of ultra-low noise TESs onboard SPICA/SAFARI

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We have been developing ultra low noise Transition Edge Sensors (TESs) based on a superconducting TiAu bilayer on a suspended silicon nitride (SiN) membrane with narrow, thin and long SiN legs. Our TESs will be used in the SAFARI instrument onboard SPICA, which has continuous spectroscopic capability in the wavelength range from 34 to 230 μm. SAFARI/TESs are required to have an electrical Noise Equivalent Power (NEP) of $\leq 3 \times 10^{-19}$ W/$\sqrt{\text{Hz}}$ to make natural background-limited observations.

Previously, we have reported NEPs of 4×10^{-19} W/$\sqrt{\text{Hz}}$ for TESs fabricated by wet etching. To achieve the required NEP, further reduction of thermal conductance should be realized and thus the fabrication of narrower (< 1 μm), thinner (< 0.25 μm) and longer (> 400 μm) SiN legs is essential. Furthermore, our TESs have shown an excess noise with respect to the phonon noise that is the intrinsic noise of TESs. Based on studies of origins of the excess noise, to reduce it, we need to fabricate TESs with lighter SiN legs and membrane.

In order to realize TESs with ultra-low and phonon-noise limited NEPs, we replaced wet etching of a Si substrate by Deep Reactive Ion Etching (DRIE). With DRIE, we fabricated a large variety of TESs with very narrow (≤ 0.6 μm) and thin (~ 0.20 μm) SiN legs and with a very thin (~ 0.20 μm) SiN membrane. As a result, we achieved phonon-noise limited NEPs $< 2 \times 10^{-19}$ W/$\sqrt{\text{Hz}}$, which are below the SAFARI requirement. The lowest NEP can make the new version of SAFARI with a grating spectrometer feasible.