Title: Proximity Effects and Nonequilibrium Superconductivity in Transition-Edge Sensors

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Abstract

We have recently shown that normal-metal/superconductor (N/S) bilayer TESs (superconducting Transition-Edge Sensors) exhibit weak-link behavior.1 Here we extend our understanding to include TESs with added noise-mitigating normal-metal structures (N structures). We find TESs with added Au structures also exhibit weak-link behavior as evidenced by exponential temperature dependence of the critical current and Josephson-like oscillations of the critical current with applied magnetic field. We explain our results in terms of an effect converse to the longitudinal proximity effect (LoPE)1, the lateral inverse proximity effect (LaiPE), for which the order parameter in the N/S bilayer is reduced due to the neighboring N structures. Resistance and critical current measurements are presented as a function of temperature and magnetic field taken on square Mo/Au bilayer TESs with lengths ranging from 8 to 130 {\mu}m with and without added N structures. We observe the inverse proximity effect on the bilayer over in-plane distances many tens of microns and find the transition shifts to lower temperatures scale approximately as the inverse square of the in- plane N-structure separation distance, without appreciable broadening of the transition width. We also present evidence for nonequilbrium superconductivity and estimate a quasiparticle lifetime of 1.8 \times 10-10 s for the bilayer. The LoPE model is also used to explain the increased conductivity at temperatures above the bilayer's steep resistive transition.