Design Constraints on Transition Edge Sensor Pixels for Filled Arrays

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We report on bolometer performance including noise and bandwidth of superconducting transition edge sensors (TES) on pixels suitable for close-packed, two-dimensional arrays. The electrothermal circuit of a TES consists of the superconducting sensor and wiring intimately coupled to a photon absorber that is thermally isolated from a heat sink held at the operation temperature of the instrument. In our case, the sensor is a Mo/Au bilayer with Mo/Nb wiring, the absorber is a shallow implanted layer or Bi film covering a silicon membrane, and the thermal isolation is micromachined constrictions in the thin (1-1.5 μm) membrane. Such a focal plane consists of metallized features making up the TES, the absorber coupled region, and vacuum gaps or supporting frame. Efforts to minimize these reflecting (TES) and transmissive (frame/gap) regions relative to the size and pixellation of the absorbing region compete with mechanical constraints as well as demonstrable electrical performance. Pixel designs for the Millimeter Bolometer Array Camera for the Atacama Cosmology Telescope and other receivers require high-speed, low-noise bolometers that can operate above 300 mK and fill the focal plane with absorber-coupled silicon membrane. Our collaborations have explored the phase space for integration of all-silicon absorbing focal planes with metallic detector components for 90 to 280 GHz imaging. We describe the results obtained during this pixel optimization. As possible, we generalize our study to TES designs for anticipated performance of direct-coupled focal planes operated at other bath temperatures and sensitive at other frequencies.