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Demonstration of fine-pitch high resolution X-ray transition-edge sensor microcalorimeters optimized for energies below 1 keV

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We are developing arrays of fine-pitch X-ray transition-edge sensor (TES) microcalorimeters for use in future space-based X-ray astrophysics missions such as the proposed Lynx X-ray Microcalorimeter. In this contribution we discuss arrays optimized to have the best possible energy resolution for a limited energy range for the incoming X-rays, such as up to ~0.8 keV for the Lynx Ultra-Hi-Res array. This array requires an energy resolution of 0.3 eV full width half maximum (FWHM) for energies up to 0.8 keV. The test array we have fabricated has 60 $\times$ 60 sensors on a pitch of 50 μm. The TES size is 20 μm, and the pixels have 46 $\times$ 46 $\times$ 1 μm^3 gold absorbers. For this array, the internal 64 pixels are wired using buried multilayer microstrip wires, wired with a density consistent with being able to wire out the complete array. We measured a spectral energy resolution of the same device using 3 eV EUV photons delivered through an optical fiber. Due to difficulties associated with directing a large number of photons into such a small pixel and produced by a short pulse on the UV laser-diode, also due to difficulties in aligning the optical fiber in our set-up we have only observed 3, 6, and 9 eV combs in spectra. For the one-photon 3 eV line we have obtained an energy resolution of 0.26 eV FWHM, which is consistent with the estimated performance based on the signal size and noise. Further measurements will determine how the energy resolution degrades with energy. But it appears that this level of energy resolution should be achievable up to 0.5 keV, and the performance gradually degrades to a measured energy resolution of around 2.3 eV at 1.5 keV using standard optimal filtering as the signals become non-linear. In this paper we will describe the full design and characterization of this detector, and discuss the performance limits of pixels designs like this.

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

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