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Development of large-scale magnetic calorimeter arrays

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We describe performance of large-scale arrays of metallic magnetic calorimeters (MMCs) we are developing to meet requirements of the Lynx X-ray Microcalorimeter (LXM) instrument in the astrophysics mission concept Lynx. We have fabricated prototypes with 55,800 x-ray pixels thermally connected to 5,688 MMC sensors. Subarrays demonstrate three types of pixels, which have different energy and spatial resolution goals in LXM. Pixel pitch is 50 or 25 μm. For two subarrays, use of position sensitive detectors, in a "hydra"configuration with 25 x-ray absorbers per sensor, helps achieve a large focal plane by increasing pixel count relative to readout channels. Since each absorber has a different thermal link to its sensor, it generates a different pulse shape and enables discrimination of pixel position. Superconducting wiring from all sensors was brought out to the perimeter of the overall array using multiple buried metal layers planarized by Chemical Mechanical Planarization to achieve high critical current, low inductance, and high fabrication yield. An automated, algorithmic approach was used to layout the complex wiring pattern. For readout with existing small arrays of Superconducting Quantum Interference (SQUID) amplifiers, 112 selected pixels were connected to wire bond pads. In hydras, we successfully identified 25 pulse shapes using rise-time and pulse height. Pulse shapes were similar to simulations. We measured noise and responsivity to substrate temperature and applied x-ray pulses. While we designed sensors to have high inductance to relative to stray inductance of wiring, we had only mismatched (lower input inductance) SQUIDs available in our current apparatus, giving non-optimized resolution. We compared measured and calculated energy resolutions. We have the required sensitivity to reach < 3 eV FWHM resolution for 6 keV x-rays, required for the LXM Main Array, and the ability to discriminate the 25 different absorber pixels down to energies < 300 eV.

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

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