MATTER AND TECHNOLOGIES

Contribution ID: **98** Type: **not specified**

Soft and hard x-ray spectroscopy with a novel calorimetric superconducting quantum sensor

Wednesday 18 September 2024 17:00 (3 minutes)

X-ray spectroscopy at synchrotron light sources has emerged as one of the most powerful tools available worldwide for the characterization of the chemical, atomic, and electronic properties of materials. While existing x-ray spectrometers provide either excellent energy resolution at low efficiency or moderate energy resolution at high efficiency, magnetic microcalorimeters (MMCs) might be a "gamechanger"as they promise outstanding energy resolution with a ΔE_{FWHM} of 1.25 eV at 5.9 keV [1], a large energy bandwidth, and extremely high detection efficiency. MMCs are ultra-sensitive cryogenic detectors which rely on converting the energy from incident photons into heat. Using an ultra-sensitive thermometer based on the temperature-dependent magnetization of a paramagnetic material in a weak magnetic field, the resulting change in magnetization is sensed with a superconducting quantum interference device (SQUID) [2].
The goal of our activities within the project "Quantum sensor platform for synchrotron x-ray spectroscopy (QUASY)", is to demonstrate the feasibility of such a x-ray quantum sensor array at multiple synchrotron radiation beamlines (i.e., X-SPEC, CAT-ACT, INE, and SUL-X) at the KIT Light Source using a universal, compact, and modular platform. In this contribution, the current design concept of the platform, which contains x-ray optics and filter foils, will be discussed. We will show first experimental data on the thin filter foils that serve as candidates to block infrared radiation while transmitting x-rays in the soft, tender, and hard x-ray energy regions. If successful, the new instrumentation will not only greatly advance the available experimental techniques, but also allow for the study of samples containing radionuclide materials, with low concentrations, and/or in in situ and operando environments.

[1] Krantz, M.; Toschi, F.; Maier, B.; Heine, G.; Enss, C.; Kempf, S. Magnetic Microcalorimeter with Paramagnetic Temperature Sensors and Integrated Dc-SQUID Readout for High-Resolution X-Ray Emission Spectroscopy. Appl. Phys. Lett. 2024, 124 (3), 032601. https://doi.org/10.1063/5.0180903.
[2] Kempf, S.; Fleischmann, A.; Gastaldo, L.; Enss, C. Physics and Applications of Metallic Magnetic Calorimeters. J. Low Temp. Phys. 2018, 193 (3–4), 365–379. https://doi.org/10.1007/s10909-018-1891-6.

Speed talk:

Normal speed talk selection

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Session Classification: Poster