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Microscopy and Microanalysis, **30** (Suppl 1), 2024, 1564–1565
https://doi.org/10.1093/mam/ozae044.772

Microscopy AND Microanalysis

Meeting-report

Detecting Magnon-Phonon Coupling in the Scanning Transmission Electron Microscope

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Magnons are a type of collective excitation which transmit a precession of magnetic moment through a material. Magnons may be able to transmit information over macroscopic distances without ohmic losses, making them especially tempting as information carriers [1]. Understanding how the bonding and local structure of a material affects magnon behavior is of necessary to create a real-world application with magnons. Traditional characterization methods, such as Inelastic Neutron Scattering or Raman Spectroscopy, can be a powerful tool to detect magnons, but they provide relatively delocalized information about the sample. The next step in the evolution of vibrational spectroscopy is to leverage the flexibility and spatial resolution of scanning transmission electron microscopy (STEM) to collect localized vibrational data using electron energy-loss spectroscopy (EELS) [2].

Constant advances in electron detectors, spectrometers, and sources have improved the energy resolution of STEM-EELS to <5meV on commercially available microscopes [3]. The weak interaction of magnons with the electron beam will make magnon excitations very difficult to detect directly with EELS, but magnons and phonons interact with each other in some materials, which can induce energy shifts due to avoided crossing [4, 5].

Here, we utilize *in situ* heating holders to perform temperature-dependent vibrational studies of yttrium iron garnet (YIG) flakes in a monochromated STEM. Yttrium Iron Garnet (YIG) is an extensively investigated magnetic insulator, which has demonstrated that strong magnon-phonon directly mediates the temperature-dependence of YIG in temperature regimes accessible in the microscope [6]. Figure 1 shows the difference between the room temperature spectrum (blue) and the elevated temperature spectrum (orange) on the same flake, exhibiting a 2.5 meV shift. The ability to measure subtle temperature-dependent shifts in the vibrational frequencies of nanoscale flakes demonstrates the ability to study magnon-phonon coupling in the STEM with unprecedented spatial resolution [7].

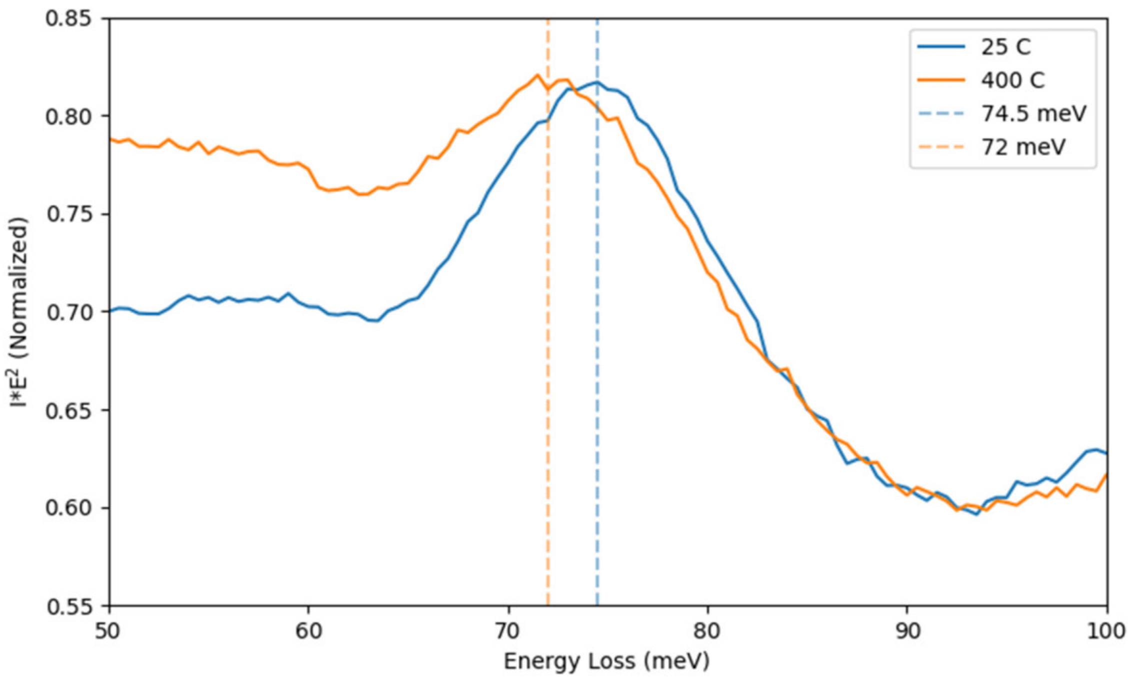

Fig. 1. EELS spectra collected on the Nion UltraSTEM at 60kV at room and elevated temperatures. The FWHM of both spectra is 8meV. The intensity axis is multiplied by the energy loss squared to improve the visibility of the peaks.

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7. The authors gratefully acknowledge funding from the Center for Emergent Materials at The Ohio State University, an NSF MRSEC (DMR-2011876). Electron energy loss spectroscopy was conducted as part of a user project at the Center for Nanophase Materials Sciences (CNMS), which is a US Department of Energy, Office of Science User Facility at Oak Ridge National Laboratory.