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A Synchrotron Far-Infrared Microspectroscopy Facility at Beamline U4IR

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Beamline(s): U4IR

Many inorganic, mineral, and semiconductor materials have low energy vibrational modes or crystal lattice phonon modes that are not typically accessible using conventional mid-infrared spectrometers. Additionally, when these samples are of minute dimensions or are extremely heterogeneous, a microscopic analysis technique is required to collect spectra of the sample or its component domains. In response to the need to analyze such samples, we have constructed a far-IR microspectroscopy facility at beamline U4IR. This development has extended the long wavelength spectral range of a conventional IR microscope to below 50 cm^{-1} (200 μm) while maintaining its performance in the mid-IR. A commercial microscope system, upgraded with a custom-built Si beamsplitter and an external Si bolometer detector, uses the synchrotron beam in lieu of a typical thermal source. The large far-IR flux of the synchrotron source, in combination with its brightness advantage, makes possible the long wavelength examination of minute or heterogeneous samples.

The system's photometric accuracy was tested by measuring the specular reflectance of various optical materials. Figure 1 shows reflectance data collected from a newly purchased salt crystal, purportedly of KBr (red circles). A comparison between the experimental data and a model spectrum of KBr (blue line) showed that the crystal had been mislabeled by the manufacturer. A rough calculation of the sample's density indicated that the crystal was likely to be of KCl. Band frequencies for the three optical phonons (ω_{TO}), their plasma frequencies (ω_P) and oscillator strengths (γ) as well as the material's dielectric constant at infinite frequency (ε_{inf}) were determined from a fit of the experimental reflectance data using three Lorentzian oscillators (black line). These values matched those in the literature for KCl to within approximately 0.5%, confirming the sample's identity. Since determining the performance characteristics of the instrumentation, the microscope has been used successfully in the identification of mineralogical components in 20 μm diameter interplanetary dust particles.

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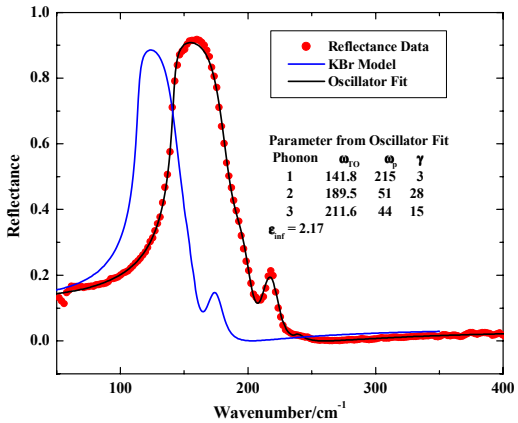

Figure 1. Specular reflectance of KCl crystal collected using a far-IR synchrotron microscope at U4IR.