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HIGH PRECISION LASER REFRACTOMETER FOR MEASUREMENT OF MINERAL INDICES OF REFRACTION

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Inspired by the jeweler's refractometer,[1] we have designed a laser refractometer capable of measuring refractive indices of mineralogical samples with high precision, approaching 1 part in 10^5. The refractometer uses a He-Ne laser of wavelength 632.8 nm to illuminate the planar surface of a glass hemisphere made of SF-11 Schott glass with index 1.77862 at 632.8 nm. The laser beam enters the curved hemispherical surface from below and is focused to a diffraction-limited spot size of 5 μm at the center of the planar surface. All the rays in the focused beam enter the hemisphere along a diagonal and therefore suffer no refraction at the surface. The mineralogical sample to be measured (typically a thin section) sits on top of the planar hemisphere surface. Rays striking the hemisphere-sample boundary at shallow angles above the critical angle for total internal reflection (TIR) are 100% reflected, whereas rays entering more steeply are only partially reflected, producing a dark-bright boundary in the reflected beam. The position of the TIR boundary in the out-going beam is measured using a linear CCD array with 7-μm pixel resolution, and Snell's law then gives the desired index in terms of the critical angle. We have used a set of known index standards to calibrate our instrument and correlate pixel number with angle.

Using the calibration we have successfully measured the indices of a number of isotropic "unknown" index standards. Because of the tightly focused beam, our instrument also has high spatial resolution, so the index of individual grains within a sample can be measured. The instrument is non-destructive and will accommodate virtually any sample with a polished surface. The hemisphere/sample assembly sits in a rotation platform so that the crystal orientation can be smoothly varied. The refractometer design can thus accommodate anisotropic crystals, with the goal of measuring two (uniaxial crystals) or three (biaxial crystals) refractive indices on a single surface with high precision.

[1]C.S. Hurlbut, Jr., "The jeweler's refractometer as a mineralogical tool," Amer. Mineral. 69, 391-398 (1984).

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