MECHANICAL PHASE MAPPING OF METEORITES: COMBINING EDX AND NANOINDENTATION

Jeffrey M. Wheeler, Laboratory for Nanometallurgy, ETH Zurich, , Switzerland
Jeff.Wheeler@mat.ethz.ch

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Meteorites are perhaps one of the most tangible aspects of outer space. With their irregular, ablated surfaces and intricate Widmanstätten microstructures, they truly appear to be otherworldly. The internal microstructure and composition of meteorites has been intensively studied and classified by astro- and geo-chemists to study their origins and formation processes [1]. However, other than some microhardness testing in the 1950s [2], very little has been done to characterize the mechanical behavior of these unique pieces of other worlds. With the advent of modern, high speed nanoindentation techniques, it is now possible to map the mechanical features of materials over square millimeters of area with micron-level resolution in a reasonable amount of time.

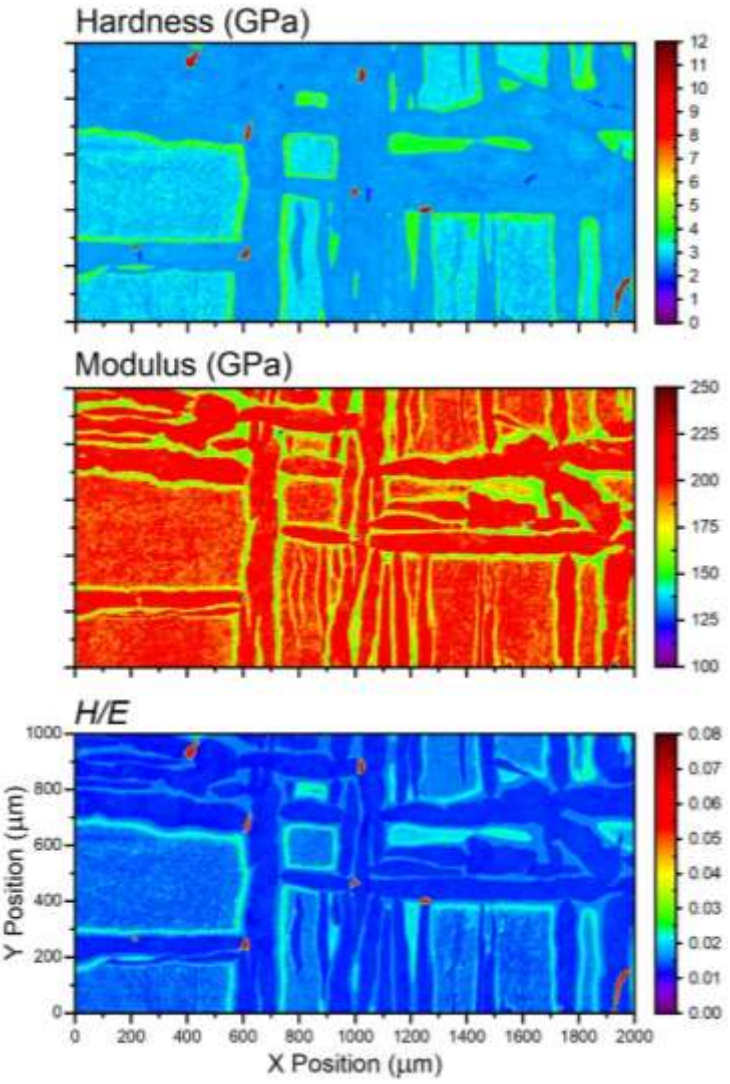

Figure 1 – Nanoindentation maps of the Hardness, Modulus and H/E ratio of a region of the Taza meteorite showing Kamacite bands in a Plessite matrix.

Nickel-iron meteorites can display a wide range of microstructures depending primarily on their nickel content, cooling rate, and tertiary composition. These range from a pure BCC iron phase (Kamacite) at low nickel concentrations to a pure FCC phase (Taenite) at high nickel concentrations. In between these concentrations, several different mixed phases occur yielding either large Widmanstätten bands of Kamacite in Taenite or a spinodally decomposed Plessite phase [1]. In **Error! Reference source not found.**, soft Kamacite bands can be see in a harder Plessite matrix in the Taza meteorite, along with several hard Schreibersite precipitates. In addition to these three phases, two additional phases can be seen to surround the Kamacite bands in the *H/E* map – TetraTaenite and the Cloudy Zone. These phases appear continuous in EDX scans, but discretely appear in mechanical phase maps.

Using statistical analysis [3], the properties of each of these phases can be extracted. By combining this information with EDX maps, the relationship between composition and properties of the various phases can be elucidated. In this work, high speed nanoindentation is combined with energy-dispersive X-ray spectroscopy (EDX) to map the mechanical properties of a variety of different nickel-iron meteorites.

References

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