SINGLE-ATOM-SENSITIVITY ELECTRON MICROSCOPY OF EARLY SOLAR SYSTEM MATERIALS.

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Introduction: Comets and asteroids contain materials that record early Solar System processes at a variety of length scales, from millimeters to single atoms. Aberration-corrected scanning transmission electron microscopy analysis has a key role to play in improving our understanding of the early Solar System by revealing processing records through imaging and elemental analysis with sensitivity down to individual atoms. At the Naval Research Lab, we have recently commissioned a custom Nion UltraSTEM 200 that provides single-atom-sensitivity imaging, electron energy loss spectroscopy (EELS) and energy dispersive x-ray spectroscopy (EDXS). UltraSTEM analyses of many kinds of planetary materials, including meteorites [1, 2], Stardust cometary samples [3], and synthetic analog materials are now ongoing [4]. Analysis of Hayabusa samples is planned, after allocation of samples approved during the AO-3 proposal cycle.

Example Results: Recent analysis of meteoritic nanodiamonds d**e**monstrate the ability to analyze the composition of individual nanodiamonds, including single impurity atoms, with EDXS [5]. Better understanding of the distribution of these impurities has the potential to directly distinguish nanodiamonds with different cosmic origins (interstellar, circumstellar or Solar System). Analysis of organic residues from primitive CO3 meteorites has revealed spatial heterogeneity in the C functional chemistry, including large variations in the S content, likely due to nanoscale variations in parent-body thermal alteration [6]. Imaging of "Q"-gas rich meteorite residues, and UV-irradiated synthetic organic polymers show similar short-range graphene-like domains.

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