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The Ultra-stable Scanning Transmission Electron Holography Microscope

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The Scanning Transmission Electron Holography Microscope (STEHM), an eleven year project, will finish its installation in March, 2013 at the University of Victoria, Canada. The STEHM is an ultra-high resolution, ultra-stable electron microscope maintaining its atomic resolution stability for recording times of 120 s, Fig. 1, an unprecedented length of time. Other than the inherent stability of its electron optical system, the residual stability of the STEHM required for long exposure recording times of its high resolution images is a stable laboratory in which it is housed. Its mechanical stability is achieved by placing its foundation separate from the building's foundation directly onto bedrock enabling it to only feel the vibrations of the Earth. Its temperature stability, $\pm$ 0.025 ^{o}C per hr, is achieved by thermal insulation of its walls, diffuse air entrance into its room and cooling panels on its walls. It is protected against stray magnetic fields by mu metal shielding and stray electromagnetic fields by one of its walls consisting of a layer of Aluminum. The room pressure is stabilized against barometric fluctuations by maintaining an over-pressurized state. Acoustic noise is deadened using acoustic wall panels. A service room on the building's foundation placed beside the lab is used to house noisy pumps and heat generating, noisy power supplies. The long recording times now possible enable very low dose imaging conditions often necessary for electron beam sensitive specimens.

The STEHM has several special features whose performance will be measured upon the completion of its installation including a high coherence, high brightness cold-FEG electron source maintaining high stability over long periods of time. The STEHM is the first aplanatic TEM [1, 2, 3] having a spherical aberration (Cs) and coma aberration corrector that enables an increase in the field of view of its high spatial resolution images from ~110 nm diameter for a standard Cs-corrected TEM to ~1100 nm diameter (scattering angle up to 65 mrad), i.e., a 10x increase. The STEHM is the first STEM to have a Cs and chromatic aberration (Cc) corrector enabling the formation of an ultra-small electron probe for investigating the atomic and sub-atomic world necessary, for example, for enhancing current limitations in confocal electron microscopy. The STEHM is the first electron microscope to have four electron biprisms that will enhance current methods of electron holography and enable the creation of new beam interference methods such as confocal electron holography [4]. The STEHM is one of the first electron microscopes that will use dislocated holograms to create electron vortex beams with optical angular momentum to manipulate the specimen's electrons, atoms and molecules from the sub-atomic scale to the micron scale with possible enhancement of both the image resolution and analytical capabilities and may enable the creation of electron spin momentum beams and spin polarized electrons using the Wien filter of its STEM aberration corrector. The STEHM has full analytical capabilities that can determine the types of atoms present and their bonding states, as well as, an imaging energy filter that enables, for example, energy-filtered electron holography to measure the coherence of quasiparticles (phonons, plasmons, magnons, etc), intraband energy states (excitons, dopants, defects), magnetic fields (domains and their boundaries), electrostatic fields (electron bonding densities) using high resolution cameras for collecting data that sometimes requires long exposure times, a capability verified in Fig. 1, for beam sensitive specimen, rending the data useful for analysis.

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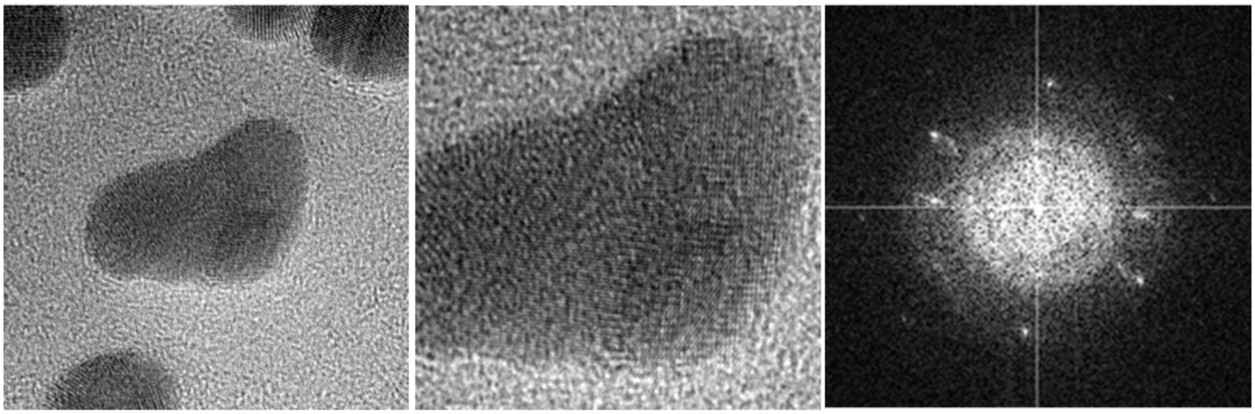

a b c

Figure 1. a) shows a TEM image of gold crystals on an amorphous carbon substrate taken for 120 seconds, the maximum recording time available, using the Gatan USC 1004 2k x 2k camera, b) shows an enlargement of the centrally located gold crystal to more easily see the presence of lattice fringes, verified in c) the Fourier transform of the image in b).

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