Application Note

Fusion™

Atomic Resolution Imaging at High Temperatures in the TEAM 0.5

Introduction

The development and widespread adoption of spherical aberration (Cs) correction systems in the TEM has enabled low to intermediate voltage (up to 300 kV) microscopes to achieve an unprecedented level of spatial resolution. New properties of materials at the atomic scale are constantly discovered on TEMs with aberration correction systems.

Utilizing the resolving power of these microscopes for *in situ* experiments will undoubtedly lead to new discoveries when materials are exposed to stimuli such as high temperature or external electric fields. The Protochips Fusion heating and electrical biasing system is designed to provide a low-drift, ultra stable platform for performing high-resolution imaging at high temperatures. The experiment described in this application note shows that the full resolution capability of your TEM can be realized with Fusion at high temperatures.

Experiment

The experiment was performed on the TEAM 0.5 TEM at the National Center for Electron Microscopy (NCEM) at Lawrence Berkeley National Laboratory (LBNL). The TEAM 0.5 is an FEI Titan cubed with probe and image Cs correctors (CEOS), a bright X-FEG electron source and a monochromator. It was operated at 300 kV for this experiment. The TEAM instrument is capable of resolving to 0.5 Å in conventional TEM mode. Gold was evaporated directly on an E-chip™, which created small gold nanoparticles directly on the E-chip. Gold provides good contrast and scattering required for resolution tests.

Discussion

Figure 1A shows a phase-contrast image of a gold

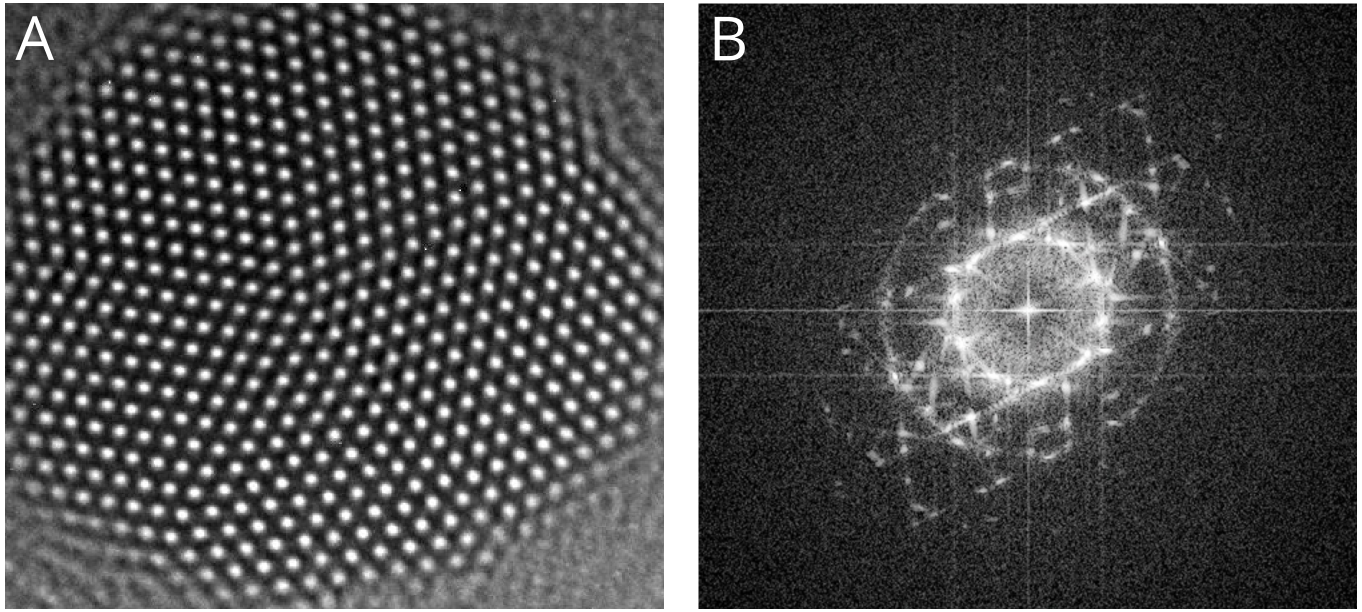

Figure 1: Gold nanoparticle at 600 °C with the corresponding FFT

nanoparticle at 600 °C. Lattice fringes at this temperature can clearly be seen, as well as the typical 5-fold faceting and twinning characteristics of gold nanoparticles. The Fast Fourier transform (FFT, Figure 1B) shows that 0.6 Å resolution was obtained at 600 °C. The resolution is close to the resolution limit of the TEM, 0.5 Å, and indicates that Fusion, even at this temperature, is not limiting the resolution of the TEM.

As the temperature was ramped from room temperature to 600 °C during the experiment, the nanoparticles became increasingly dynamic. They started to coalesce, facets changed and defects in the material became mobile. The stability of the system made imaging, including the recording of real time movies and analysis of these events possible at the atomic scale with unparalleled clarity.

Applications

Traditional and aberration corrected TEMs require a stable, low drift heating system to fully harness their resolution capabilities for imaging and analytical analysis. The Fusion heating and electrical biasing system enables atomic resolution imaging and analysis of materials and is applicable to all materials for *in situ* heating. Contact us to discuss the full range of capabilities of Fusion with Thermal E-chip sample supports. We can be reached at (919) 377-0800 or contact@protochips.com.