A versatile three-contact electrical biasing transmission electron microscope specimen holder for electron holography and electron tomography of working devices

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The concept of a 'laboratory in an electron microscope', which allows several high spatial resolution analytical techniques to be combined with experiments that are traditionally carried out ex situ, is highly attractive for tackling a wide range of problems in nanoscience and nanotechnology. We have recently developed a transmission electron microscope specimen holder that allows a sample to be examined under an applied bias using both electron holography and electron tomography, as well as allowing the same sample to be transferred easily to a scanning electron microscope, a focused ion beam workstation, a plasma cleaner and an argon ion miller in a universal cartridge assembly. Within the cartridge, two independent electrical contacts can be made to either the surface or the sides of the specimen. When the cartridge is located in the specimen holder, a third electrical contact (typically an etched tungsten needle) can be moved towards the specimen using piezoelectric drives. Tilts of up to 70 degrees can be achieved before the central 0.5 mm of the sample begins to be shadowed by the edges of the holder. I will demonstrate recent results from the use of this specimen holder to characterize electrostatic and magnetic fields in working devices, including field emitters and electrical circuits patterned onto electron-transparent films, using off-axis electron holography. I will also demonstrate the use of the holder to perform nanoindentation experiments, and the design of an alternative cartridge geometry that allows samples to be heated to 1500 degrees C during examination in the electron microscope.