Nanoelectromechanical systems on a Si-on-insulator chip to act on the phase of the electron wave-field inside a transmission electron microscope

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For various applications, the electron wave-field propagating through the electron column in a transmission electron microscope (TEM) needs to be spatially tuned at the sub-micrometer scale [1,2]. It is currently performed using macroscopic electron-optics elements such as aberration-correctors or focus ion beam (FIB) processed structures [3,4]. These approaches are time consuming and/or expensive to fabricate. An alternative approach is to use semiconductor processing technology to fabrication devices which act on the electron wave-field through sub-micrometer electrostatic poles. Nanoelectromechanical systems (NEMS) are a class of devices which integrate mechanical functionality on the nanoscale fabricated using semiconductor processing technology. Their nanometer dimensions lead to low mass, high mechanical resonance frequencies and strong electrostatic fields.

Off-axis electron holography allows both the amplitude and the phase shift of an electron wave-field propagating through a specimen in a TEM to be recovered. The technique requires the use of an electron biprism to deflect an object wave and a reference wave to form an interference pattern. Most implementations of the technique rely on the deflection of electrons that have passed through the specimen towards a vacuum reference electron wave using a Möllenstedt–Düker electron biprism, which normally takes the form of a sub-micrometer-diameter metal or metal-coated quartz wire [5,6] that is located close to a conjugate image plane in the microscope (in an aperture holder). Despite considerable progress in many aspects of instrumentation for electron microscopy, little has been done to improve the design and manufacture of electron biprisms.

Here, we present an approach to fabricate fine electron biprisms with rectangular cross-sections using NEMS technology. A dedicated chip holder which was designed, machined and used to test the biprism in the selected area (SA) aperture plane of a Philips CM20 FEG TEM. We also performed electrostatic calculations and preliminary experiments demonstrate that such biprisms promise improved performance for electron holography experiments. The holograms obtained with this setup have as an overlap width of 45 nm, an interference fringe spacing of 0.2 nm and an interference fringe contrast of 16% for 27 V applied to the
rectangular biprism [7,8]. We will also present a proof-of-concept of a dedicated chip holder to be inserted in the condenser system of a Jeol ARM200F probe corrected TEM.

References


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