Electron holography using femtosecond electron pulses

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Off-axis electron holography in the Transmission Electron Microscope (TEM) is a well established technique used to quantitatively map the magnetic, electrostatic and strain fields around, and inside, materials or devices at the nanoscale [1]. The spatial coherence of the electron source is the key parameter to obtain electron holograms with sufficiently high signal to noise ratio. Electron holography performed with thermionic source is impossible and demands TEMs based on Field Emission (FE) electron sources to obtain useful hologram for materials characterization. Even in this latter case, the experimental conditions need to be carefully optimized. In particular, a special attention has to be paid to the illumination conditions (elliptic with an optimized shape ratio), the fringe spacing, the hologram overlap, the magnification and the exposure time to minimize the transfer function contribution of CCD camera, biprism wire vibration, " All these parameters have been extensively studied for standard continuous FE-TEM [2].

Based on laser-driven nanoemitters, new ultrafast FE-TEMs have recently been developed enabling electron holography with ultrashort electron pulses [3,4]. However, even if the instantaneous brightness is similar in continuous and ultrafast operation modes, the electron dose in the sample plane is considerably reduced due to the low repetition rate of the photon/electron pulse train. This peculiar property of ultrafast FE-TEMs means that ultrafast holograms are acquired in the "low dose" mode of the microscope. As a consequence, the experimental parameters commonly used for the acquisition of off-axis electron holograms with conventional TEMs cannot be directly implemented in the ultrafast mode [5].

Experimental studies were undertaken to find the optimum conditions for ultrafast off-axis electron holography. The influence of the dose, the coherence length of the source, the illumination condition and the instrument instabilities have been addressed.

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