Transmission through thin films by low energy scanning electron microscopy

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Transparency of free-standing thin films is being tested for purposes of supporting biological macromolecules to be imaged by holography with low energy electrons [1].

A carbon foil of 10 nm in thickness was prepared by magnetron sputtering in nitrogen atmosphere on a flat glass covered by a disaccharide layer. Disaccharide was dissolved in distilled water, dropped on glass, dried, covered with carbon, and the foil was unstuck on a 25 μm period standard copper TEM grid. The foil thickness was measured by the X-ray diffraction. The experiment was made in the ultrahigh vacuum scanning low energy electron microscope equipped with the cathode lens providing high resolution imaging in both reflected and transmitted modes [2, 3]. The 6 keV primary electrons were decelerated in front of the specimen by its negative potential to their final landing energy fluently controlled by the specimen bias. With the same field the signal electrons were accelerated toward detectors held on the ground potential. Detectors for reflected and transmitted electrons were positioned closely above and below the specimen, respectively.

According to expectance, at high electron energies (above 6 keV) the foil is fully transparent. The transparency drops with decreasing landing energy and the grid becomes hidden below the foil. However, at lowest energies (20 eV) the grid is well visible again so the electron transmission obviously increases (Fig. 1). Charging caused by insufficient conductivity of the foil and creating a non-uniform potential within the grid hole causes the foil acting as an electron mirror (see Figure 1, reflected mode at 20 eV) and hence prevents electrons from their transmission. For improvement, copper grids covered with holey carbon foil (Quantifoil) were used as the support for a 3 nm gold film prepared by the above mentioned procedure. Images in the transmitted electron (TE) mode (Fig. 2) demonstrate good transparency of the Au film even at 10 eV. The contrast development well agrees with the Monte Carlo simulations.

Assembly of the cathode lens with the couple of detectors enables one to inspect the electron transmission through free standing thin foils. The TE images at very low energies exhibit substantially enhanced contrast, obviously showing thickness variations in units of monolayers. The experiments are continuing with graphene samples. [4].

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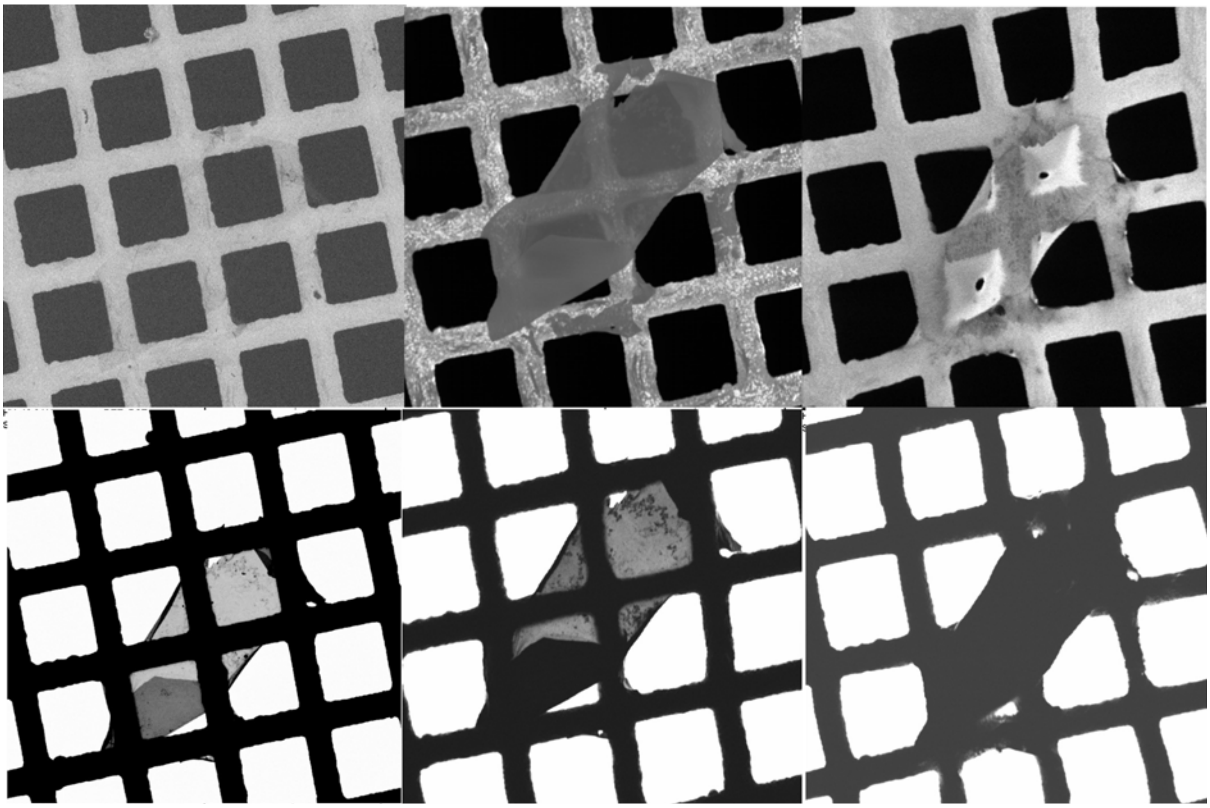

Figure 1: 10 nm carbon foil on a 25 µm period Cu grid: reflected electron micrographs (upper row) and transmitted electron images (lower row), electron energies from the left: 6 000 eV, 400 eV, 20 eV.

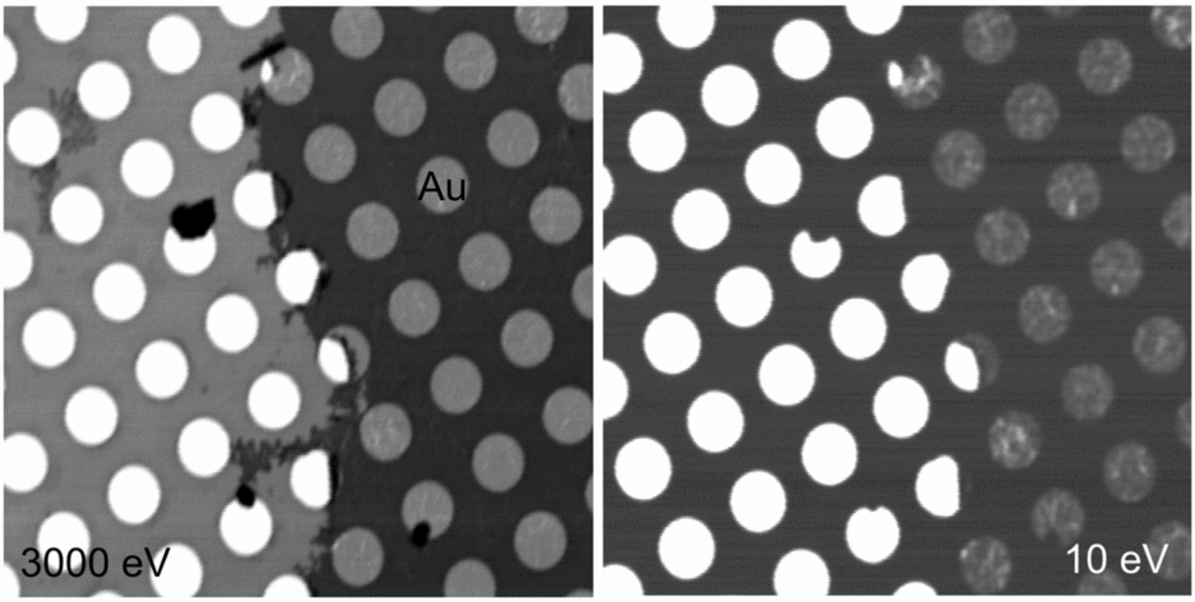

Figure 2: Transmitted electron micrographs of the Quantifoil (holey carbon film of 12 nm in thickness with round holes of 2 µm in diameter) with the right part covered by a 3 nm gold film.

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