Imaging interfacial water and it's dynamics at nm resolution and real time by transmission electron microscopy

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We will discuss the following topics:

1. fabrication of a 2.7x2.7mm liquid cell into which water and solutions of protein are introduced and sealed against the vacuum of a 120 or 200 kV TEM
2. the liquid cell windows are 10-50 nm thick and made of Si3N6, plasma-cleaned and rendered hydrophilic by glow discharge, the water fills a 100-200nm gap between the windows
3. observations are recorded at 20 fps by a 2Kx2K CCD camera
4. constant irradiation from a focused electron beam creates a void in the water column and dewetting of the window surfaces leading to the formation of thin (10-20nm thick) sheets and droplets (10-50 nm diameter) of water
5. the droplets translocate by a stick-slip mechanism involving a transition from a hemispherical to toroid-shaped droplet
6. other dynamics are observed including droplet condensation, coalescence, and a highly dampened Brownian motion (9 logs slower than in bulk water) by 5 nm diameter gold or platinum particles
7. protein complexes including the acrosomal process and microtubules can be imaged in room temperature liquid water
8. rate of radiation damage in room temperature water is the same as in vitreous ice at liquid nitrogen temperature
9. the results

1. Mirsaidov UM, Zheng H, Bhattacharya D, Casana Y, Matsudaira P. 2012. Imaging protein structure in water at 2.7 nm resolution by TEM. Biophys J. 102:L15-7.
2. Mirsaidov UM, Zheng H, Bhattacharya D, Casana Y, Matsudaira P. 2012. Direct observation of stick-slip movements of water nanodroplets induced by an electron beam. PNAS 2012 Apr 18
3. Mirsaidov UM, Ohl, CD, Matsudaira P. 2012 Direct observation of nanometer-size void dynamics in ultra-thin water film. Soft Matter in press