doi:10.1017/S1431927614009246
Microsc. Microanal. 20 (Suppl 3), 2014

Nanoscale Dynamics in Ultrathin Liquids Visualized with TEM

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Nanoscale imaging of frozen aqueous specimens and solid materials with transmission electron microscopes (TEM) has revolutionized our understanding in biological and material sciences. However, there is an ample number of important problems in life and physical sciences that occur only in liquid environments. Therefore, there is an incredible advantage of being able to image nanoscale processes directly in liquids [1-3]. I will describe our recent work on development of platform for imaging soft materials and biological samples in liquids using TEM [4-6]. We use this platform to study liquid properties at nanoscale. Here we show that the properties of fluid at nanoscale dominated by its interfacial interaction with the solid substrate surface and drastically differ from the expected bulk behavior. For example, the diffusive movement and rotation of nanocrystals within liquid nanodroplets are severely dampened when compared with macroscopic fluids. We will describe dynamic processes in nanoscale fluids such as condensation of nanodroplets and flow of nanodroplets. Imaging nanoscale fluids also enabled us to observe nanocrystal nucleation through nanocluster aggregation that differs from predictions of classical nucleation theory. We observe that crystals form amorphous aggregates.

In addition, we will also describe our attempts at new all-graphene nanofluidic platforms that enable high contrast imaging of nanoscale dynamic processes in liquids (Fig. 1) [7]. Using these graphene nanochannels we have for the first time visualized the interface between water and grapheme using TEM. [7]

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[8] This work was supported by the Singapore National Research Foundation's Competitive research program funding (NRF-CRP9-2011-04).

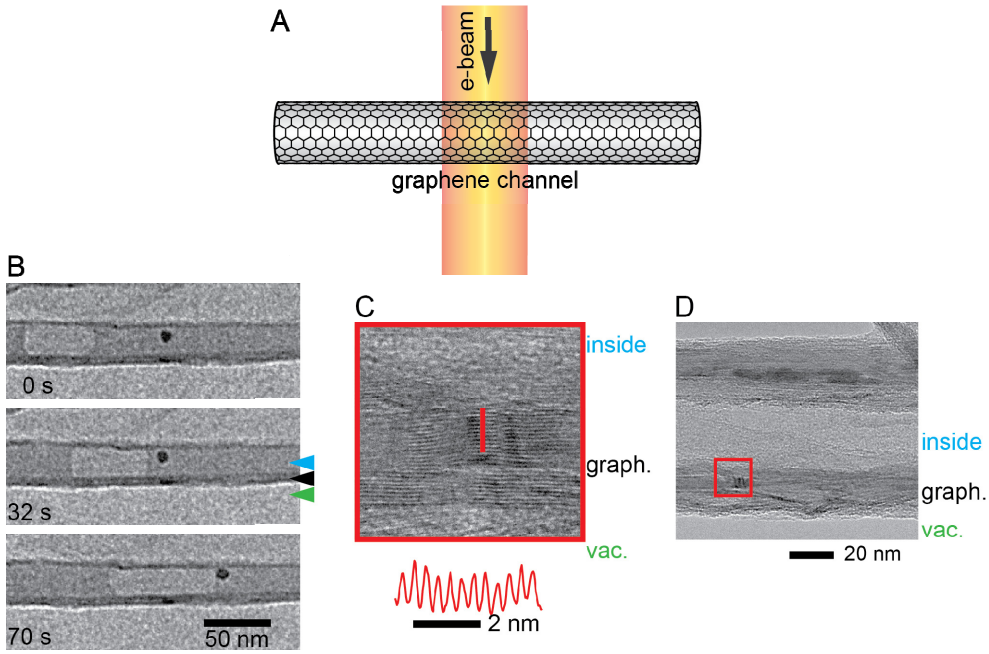

Figure 1. Graphene nanochannel platform. (A) A schematic of graphene nanoscroll. (B) The first experiments probing the interaction dynamics of nanoparticle and nanobbubles in liquids in these sealed channels. (C) Channels are formed by graphene rolling where the stacks of graphene are clearly visible in magnified region of selected area of (D) (inner wall-blue, graphene stacks-black, and outside region of the channel-green). Stacking between graphene layers is 3.4 Å.

https://doi.org/10.1017/S1431927614009246 Published online by Cambridge University Press