Mesoscale Priority Research Direction

Wetting and fluid transport phenomena under mesoscale confinement

Opportunity

Many emerging technologies related to energy harvesting, conversion and storage rely upon the wetting and transport properties of complex fluids (electrolytes, polymers, colloidal suspensions) within mesoscale (1-100 nm) structures (pores, channels). However, a comprehensive understanding of these mesoscale phenomena is still missing due to the lack of in-situ, time-resolved studies on well-characterized systems.

Approach

To successfully explore the effects of boundaries and confinement on wetting and liquid transport, well-defined mesoscale structures are essential. In-situ structural probes (coherent x-ray scattering, scanning probe) are well suited to study the dynamics of confined fluids (including infiltration, diffusion, electro-kinetics, transport coefficients, etc.)

Meso Challenge

Novel wetting, and mass/charge transport phenomena emerge for fluids confined at the mesoscale due to (1) the effect of intermolecular forces, (2) the influence of the boundaries on the liquid flow, (3) the finite length of charge screening in an electrolyte

Impact

This research will improve the basic understanding of fluid transport phenomena under mesoscale confinement and enable novel technologies aimed at energy harvesting, conversion and storage.

References:
1) R.B. Schoch, J. Han, P. Renaud "Transport phenomena in nanofluidics" Rev. Mod. Phys. **80**, 839 (2008)
2) A. Checco, "Liquid spreading under nanoscale confinement" Phys. Rev. Lett. **102**, 106103 (2009)

Contact: A. Checco

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“Wetting and fluid transport phenomena under mesoscale confinement” (Antonio Checco, BNL)

Many emerging technologies related to energy storage (lithium batteries, electrochemical capacitors) rely upon the wetting and mass/charge transport properties of complex fluids (electrolytes, polymer and colloidal suspensions) within mesoscale (1-100 nm) structures (pores, channels). At the mesoscale (see Fig. 1), the effect of intermolecular forces, hydrodynamic boundary friction (characterized by a “slip length”), and boundary charge screening (characterized by a “Debye length”) give rise to novel – and still poorly characterized – fluid transport phenomena. Fundamental understanding of these processes require developing I) engineered mesoscale structures with well-defined size and boundaries and II) a set of experimental tools (based on x-ray, scanning probe, and optical techniques) for probing the dynamics of confined fluids with high spatial resolution.

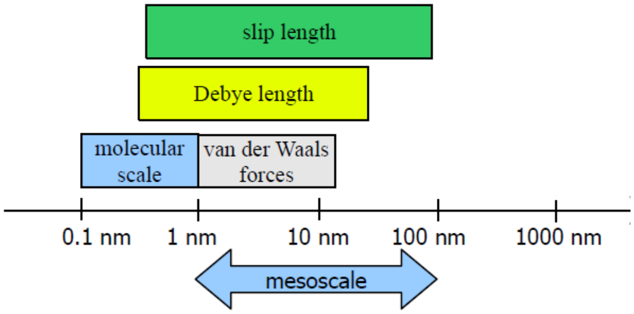

Fig. 1: Length scales at play in confined fluid transport