Soft Nanofluidics

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Liquid and ionic transport through nanometric structures is central to many phenomena, ranging from cellular exchanges to water resource management or green energy conversion. While pushing down towards molecular scales progressively unveils novel transport behaviors, reaching ultimate confinement in controlled systems remains challenging and has often involved 2D Van der Waals materials. Here, we propose an alternative route, which circumvents demanding nanofabrication steps, partially releases material constraints, and offers continuously tunable molecular confinement. This soft-matter-inspired approach is based on the spontaneous formation of a molecularly thin liquid film onto fully wettable substrates in contact with the vapor phase of the liquid. Using silicon dioxide substrates, water films ranging from angstrom to nanometric thicknesses are formed in this manner, and ionic transport within the film can then be measured. Performing conductance measurements as a function of confinement in these ultimate regimes reveals a one-molecule thick layer of fully hindered transport nearby the silica, above which continuum, bulk-like approaches account for experimental results. Overall, this work paves the way for future investigations of molecular scale nanofluidics and provides novel insights into ionic transport nearby high surface energy materials such as natural rocks and clays, building concretes, or nanoscale silica membranes used for separation and filtering.

References

[1] Aymeric Allemand, Menghua Zhao, Olivier Vincent, Remy Fulcrand, Laurent Joly, Christophe Ybert, Anne-Laure Biance, Anomalous ionic transport in tunable angstrom-size water films on silica, PNAS, 12 juin 2023, 2022-21304R.

Figures

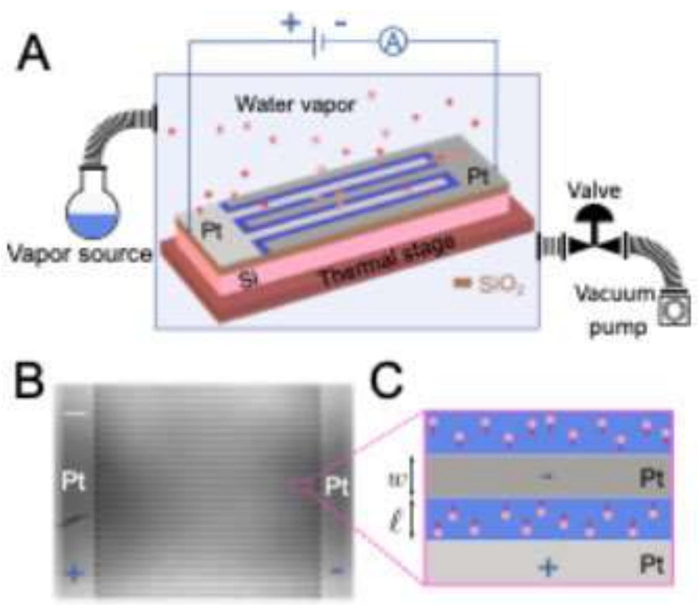

Figure 1: Scheme of the experimental setup and picture of the substrate.