Ultra-thin freestanding membranes enables new discovery of interfacial properties

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Many surface-sensitive techniques have been improved recently to narrow the gap between measuring environmental conditions from vacuum to practical gas and liquid environments. To extend the pressure range and to enable measurements of the liquid phase, thin film membranes acting as windows in environmental cells have been fabricated. Herein, we present a new generation of ultrathin free-standing membranes made with graphene, oxide films (2-10nm Al_2O_3, TiO_2, etc.) or metal (3-10nm Pt)[1]. The films are mechanically robust and transparent to electrons and photons. Their applicability for various environmental spectroscopies, such as X-ray Photoelectron Spectroscopy (XPS, 1bar for gas or for liquid), Infrared Nanospectroscopy (nano-FTIR, solid-liquid interface), Kelvin Probe Force Microscopy (KPFM) and Sum Frequency Generation (SFG) is demonstrated[1,2]. With this platform we investigated the structure and profile of electrical double layer, self-assembly of protein and electrocatalyst evolution. The remarkable properties of such ultra-thin membranes open up broad opportunities for atomic/molecular level studies of interfacial phenomena (corrosion, catalysis, electrochemical reactions, energy storage, geochemistry, and biology) in a broad range of environmental conditions.

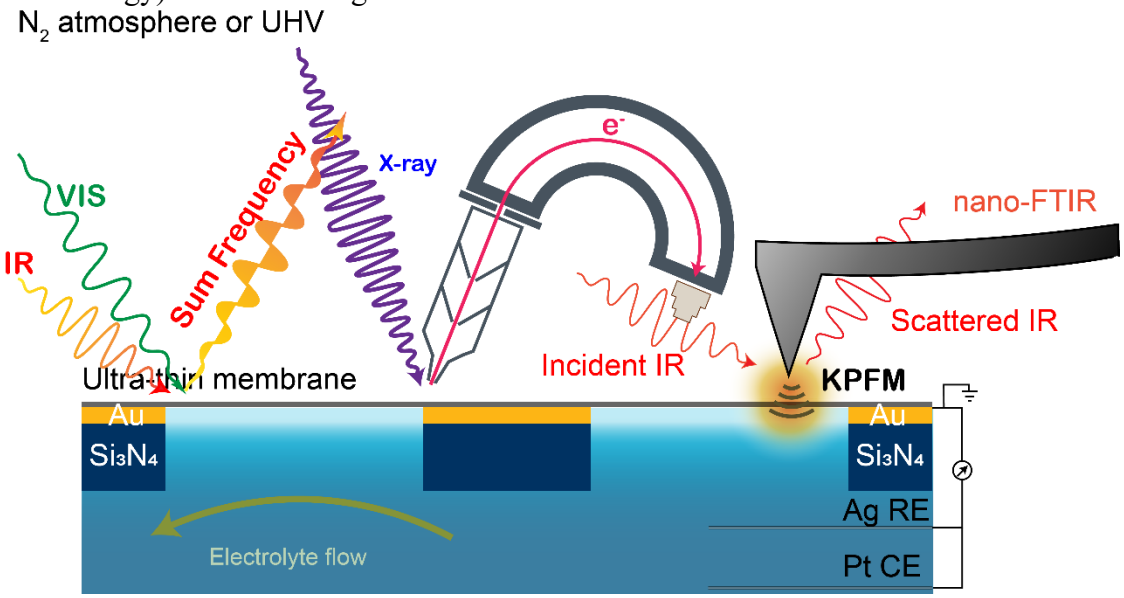

Figure 1 Schematics of liquid cell approach for the study of solid-liquid interface with ultra-thin membrane separating the liquid inside and the inert gas/UHV outside

[1] Yi-Hsien Lu, Carlos Morales, Xiao Zhao, Matthijs A. Van Spronsen, Artem Baskin, David Prendergast, Peidong Yang, Hans A. Bechtel, Edward S. Barnard, D. Frank Ogletree, Virginia Altoe, Leonardo Soriano, Adam Michael Schwartzberg, and Miquel Salmeron, Nano Lett (2020); Yi-Hsien Lu, Jonathan Michael Larson, Artem Baskin, Xiao Zhao, Paul D Ashby, David Prendergast, Hans A Bechtel, Robert Kostecki, and Miquel B Salmeron, Nano Lett (2019).

[2] Xiao Zhao, Dong Li, Yi-Hsien Lu, Behzad Rad, Chunsheng Yan, Hans A. Bechtel, Paul D. Ashby, and Miquel B. Salmeron, Proceedings of the National Academy of Sciences **119** (32) (2022); Shanshan Yang, Xiao Zhao, Yi-Hsien Lu, Edward S. Barnard, Peidong Yang, Artem Baskin, John W. Lawson, David Prendergast, and Miquel Salmeron, J Am Chem Soc (2022).

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