Free-standing self-assembled monolayered nanoparticle membranes and their electromechanical properties by conducting AFM

M. Gauvin[1], T. Alnasser[1], J. Grisolia[1], B. Viallet[1], S. Xie[2], J. Brugger[2] and L. Ressier[1]*

[1] Université de Toulouse, LPCNO, INSA-CNRS-UPS, 135 avenue de Rangueil, Toulouse 31077, France
[2] Microsystems Laboratory, Institute of Microengineering, EPFL, 1015 Lausanne, Switzerland

*laurence.ressier@insa-toulouse.fr

Abstract

Freestanding membranes of dodecanethiol coated 7nm colloidal Au nanoparticles assembled at the liquid/liquid interface [1, 2], are deposited over micrometric holes etched in Si_3N_4 substrate and addressed by gold electrodes using stencil lithography (Figure 1a). PFTUNA™ (Peak Force Tunneling AFM) cartography and spectroscopy are performed on these free-standing self-assembled nanoparticle membranes (Figure 2b). Their deformation cartography and mechanical properties are determined from AFM force-displacement curves measured across the entire membrane area. The Young modulus and pre-stress of these free-standing self-assembled nanoparticle membranes are in the range of several GPa and a few tenth of MPa respectively. Force-dependent current spectroscopy measurements are performed to study intrinsic electro-mechanical properties of monolayered nanoparticle membranes in a substrate-free configuration. On increasing the applied load, we observe an increase in the electrical resistance of the membranes as a result of the membrane deformation. To quantify this effect, the membrane deformation measured by AFM is analyzed using finite element modeling. The electrical resistance variation of the membrane as a function of deformation shows high sensitivity value of ~100. These results show that free-standing self-assembled monolayered nanoparticle membranes are potential candidates for ultra-sensitive nanosensor applications.

References

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Figure

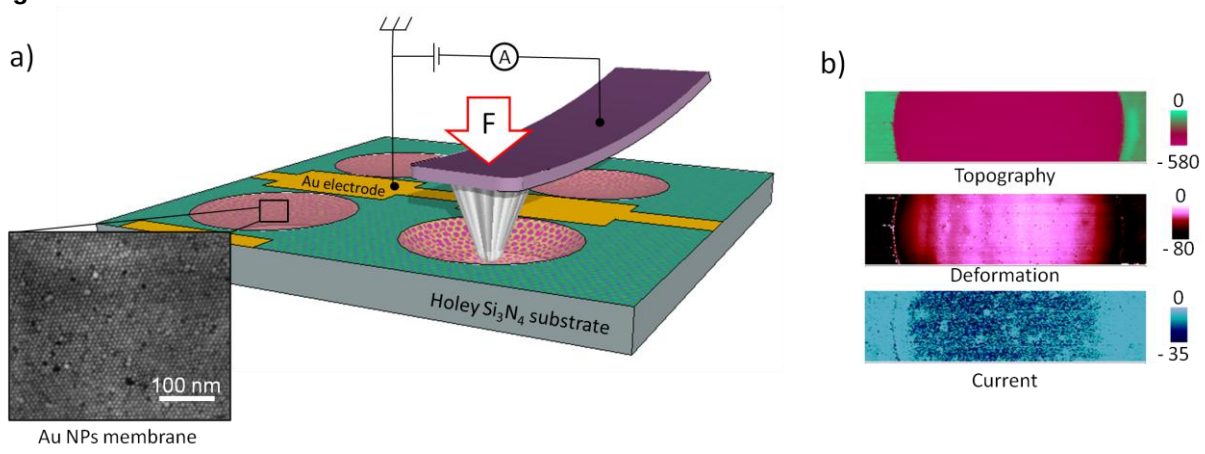

Figure 1: a) Schematic of free-standing self-assembled monolayered nanoparticle membranes deposited on holey Si_3N_4 substrate investigated by PFTUNA. Inset shows a scanning electron microscope image of the close-packed nanoparticles in the membrane. b) Typical topography, deformation and current images in PFTUNA mode of a same membrane at a fixed force setpoint of 9 nN and applied voltage of 0.5 V.