QUANTITATIVE NANOSCALE DIELECTRIC MICROSCOPY OF THIN FILMS AND BIOMEMBRANES AT LOW FREQUENCIES

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The dielectric constant of insulating materials plays a key role in many electrical, optical and biological phenomena. With scaling of technological applications toward submicro or even nanoscale lengths, the accurate measurement of this property with high spatial resolution has become increasingly important and difficult. The standard thin film characterization techniques require large-area test structures and are not capable of addressing the dielectric constant at the nanoscale. For this reason new techniques are being investigated. Some progress in this direction has been made using scanning probe techniques at microwave frequencies. However, the quantification of the dielectric constant in the low-frequency domain (<1 MHz) have not been achieved yet despite the variety of studies based on electrostatic force microscopy.

Here we will present a novel methodology implemented in our group, referred to as nanoscale dielectric microscopy (NDM) [1], which allows performing quantitative maps of the dielectric constant of ultrathin films with high precision and nanoscale spatial resolution. In NDM the dielectric constant images are reconstructed with the use of a precise analytical theoretical model [2] from local capacitance variations and thickness images. The capacitance variations in the sub-attoFarad range are probed either by *alternating current (ac) sensing* or by *force sensing* approach. The obtained dielectric constant is independent from the experimental set-up (probe radius, scan height, etc.) and represent an intrinsic property of the thin film investigated. Examples of application of NDM to thin oxide films [3] and single-layer biomembranes (Figure 1) will be provided, together with a discussion on the ultimate limits of the technique.

References:

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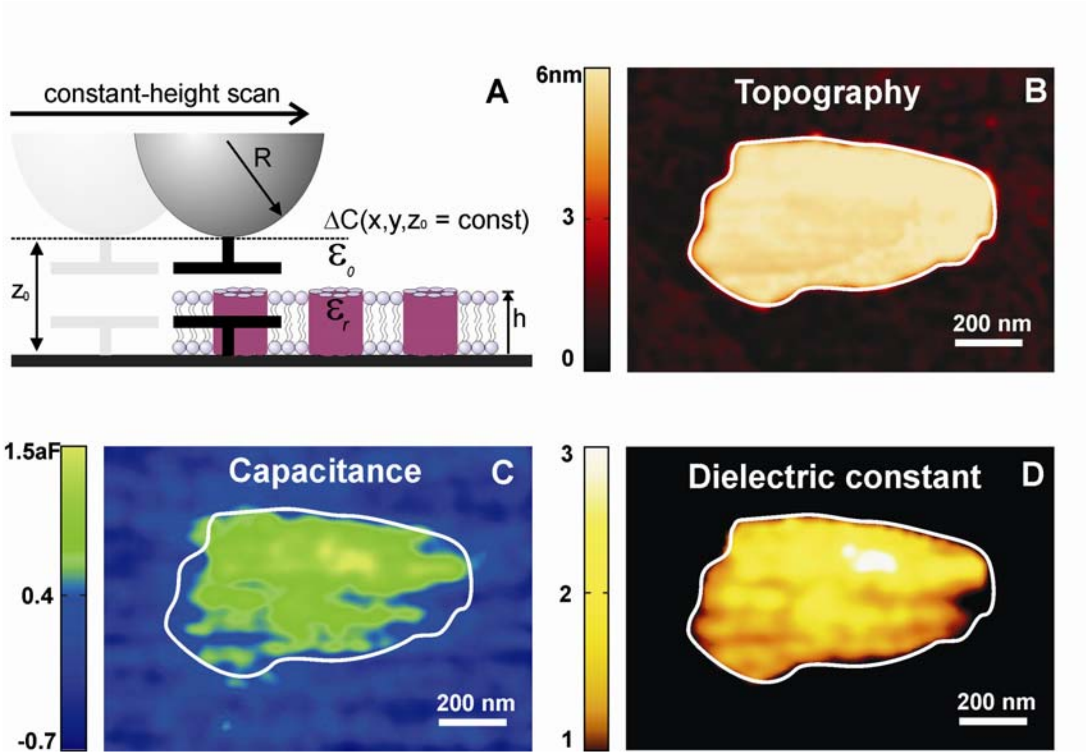

Figure 1. **(a)** Schematic representation of low-frequency Nanoscale Dielectric Microscopy (NDM). **(b)** Topography, **(c)** local capacitance image and **(d)** dielectric constant image reconstructed from (b) and (c) of a Purple Membrane fragment [1].