

## Non-electroneutrality of silica surfaces: role of water adsorption

R. F. Gouveia<sup>(1)</sup> and F. Galembeck<sup>(1)\*</sup>

(1) Institute of Chemistry, University of Campinas – UNICAMP, P. O. Box 6154, 13083-970, Campinas - SP, Brazil. E-mail: fernagal@iqm.unicamp.br

**Abstract** – This work verifies a model for the build-up and dissipation of reproducible electric potential patterns on silica surfaces, based on water adsorption, ionization and on ion migration. Electrostatic patterns were induced on silica-on-silicon films and detected by using KFM under controlled atmosphere. Pattern build-up and dissipation are faster under high humidity. Also, spontaneous patterns were detected on Stöber silica films, which change with relative humidity of the surrounding atmosphere, within a fully grounded and shielded environment thus showing that water adsorption induces change in the electrification pattern of silica, independent of charge induction.

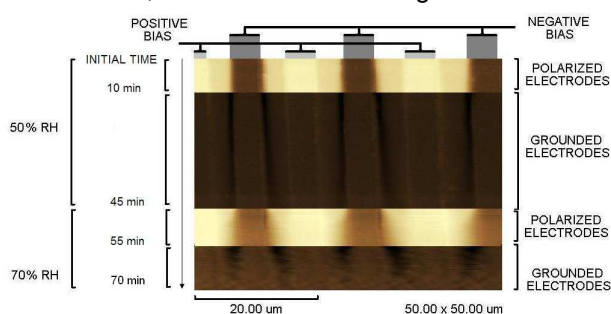
Electrostatic charging is familiar to most persons but knowledge on this topic is still rather empiric [1], mainly because fundamental ideas on the structure of matter are not well connected to the phenomenology of insulator charging. This work shows that water adsorption modifies charge status of silica and that electroneutrality is not an essential characteristic of insulating materials.

Samples were 1) silica-on-silicon thin films grown by oxidation of a silicon wafer surface, partially covered with thin stripes of gold acting as interdigitated electrodes and 2) Stöber silica particles.

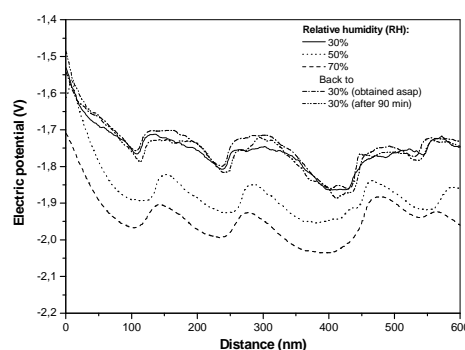
When the electrodes are connected to a DC power supply, electrostatic patterns on silica are obtained by Kelvin force microscopy (KFM) (Figure 1). Pattern formation on silica films and their dissipation are much faster at high relative humidity (RH), under an argon atmosphere. Figure 1 is a potential pattern representation in space and in time. Following the image from top to bottom, many changes are observed with time, in consecutive micrographs as well as within any micrographs recorded at 50% or 70% RH values, but when the electrodes are polarized lower than 50% RH, patterns show little or no observable changes.

KFM micrographs of Stöber silica particles change with surrounding RH. The average potential becomes more negative as RH is increased but it becomes more positive again when RH is decreased, showing that water desorption causes a decrease in the overall sample negative charge even within a grounded environment. Line scans showing potential changes at different sample pixels are in Figure 2.

Charge dissipation under high humidity is well known and it is often assigned to increased surface conductance. However, increased charge accumulation at high humidity is not expected within any models for surface charge accumulation, except those based in water ion partitioning [2-5]. Water adsorption and desorption are often assumed to involve neutral molecules only, but there is no reason why charged (ionic) water molecule clusters should not be adsorbed and desorbed, depending on their affinity for the surface components and on local electrostatic potentials. Evidence in favour of ion partitioning is currently growing in the literature, as well as the challenge on the electroneutrality paradigm [5].



**Figure 1:** KFM micrograph of a silica-on-wafer thin film partially covered with interdigitated electrodes. Successive changes on electrode polarization, acquisition time and relative humidity were made during image acquisition, as indicated at the sides of the figure. Brighter areas are positive; darker areas are negative.



**Figure 2:** Line-scans from the same line on five consecutive KFM images from Stöber silica particles deposited on Si wafer.

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