LABORATOIRE DE GÉNIE ÉLECTRIQUE DE PARIS

UMR 8507 du CNRS - Supélec - Universités Paris 6 et Paris 11
11 rue Joliot-Curie, Plateau de Moulon, 91192 GIF-SUR-YVETTE Cedex
tél. : 01 69 85 16 33 - fax : 01 69 41 83 18 – http://www.lgep.supelec.fr

Simultaneous resistance and capacitance cartography by conducting probe atomic force microscopy in contact mode

Pascal Chrétien, Frédéric Houzé, Olivier Schneegans,
René Meyer, Lionel Boyer[†]

[†] deceased

Abstract

After many years devoted to the development of the AFM extension names "Resiscope" allowing wide-range resistance measurements [1], we recently presented a new and more complete technique able to get an additional electrical information – the local capacitance – simultaneously with the topography and resistance signals [2,3]. Operating as previously in contact mode, we superimpose a small AC modulation to the DC bias and use the lock-in principle to analyze the in-phase and quadrature components of the current. Seven decades of capacitance values can be reached with the present prototype, from 10^{-17} to 10^{-10} F. This technique clearly differs from the scanning capacitance microscopy (SCM), since we intend to access absolute values of capacitance, not relative variations, while keeping high-quality measurement of the ohmic current component (from 10^{2} to 10^{12} Ω). Great attention was paid to verify the accuracy of the capacitance values. For this purpose specific calibration samples of well-defined geometry were elaborated and carefully tested, and the experimental results were compared with finite elements calculations.

[1] F. Houzé, R. Meyer, O. Schneegans, L. Boyer, *Appl. Phys. Lett.* **69** (13), p. 1975 (1996).
[2] P. Chrétien, O. Schneegans, F. Houzé, R. Meyer, L. Boyer, *Veeco User's Meeting,* Grenoble (2003).
[3] F. Houzé, P. Chrétien, O. Schneegans, R. Meyer, L. Boyer, *Appl. Phys. Lett.***86** (2005)

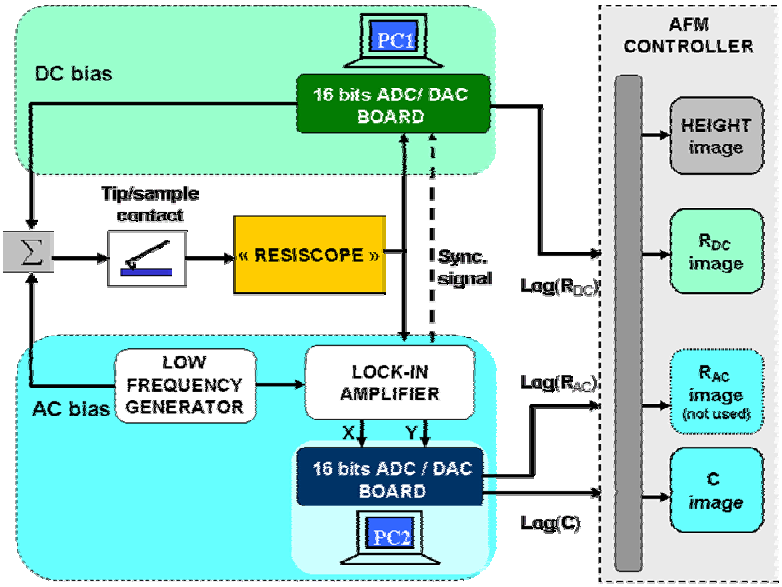

Figure 1 : *Schematic view of the experimental set-up. The notations R_{DC} and R_{AC} indicate that resistance values can be obtained either from the "Resiscope" or from the lock-in, respectively. As improving the range and the resolution of R_{AC} is to the detriment of C measurement, we currently use a mix of DC for resistance and AC for capacitance imaging.*

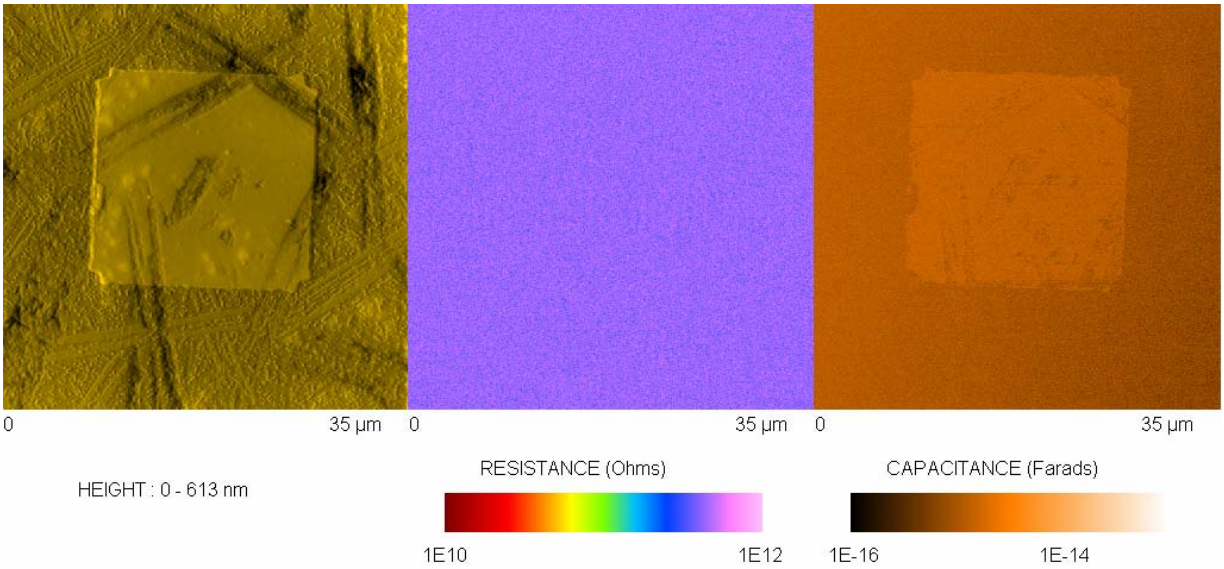

Figure 2 : *Topography (left), resistance (center) and capacitance (right) pictures simultaneously recorded on a tiny square gold plate evaporated on a Macor® substrate ; the substrate backside is fully metallized to form a plane/plane capacitor. This is a typical example where the ohmic component is helpless to get any electrical information, whereas the capacitance image clearly reveals the pattern. Experimental parameters : tip/sample DC bias +1 V, AC bias 65 mV, frequency 10 kHz.*

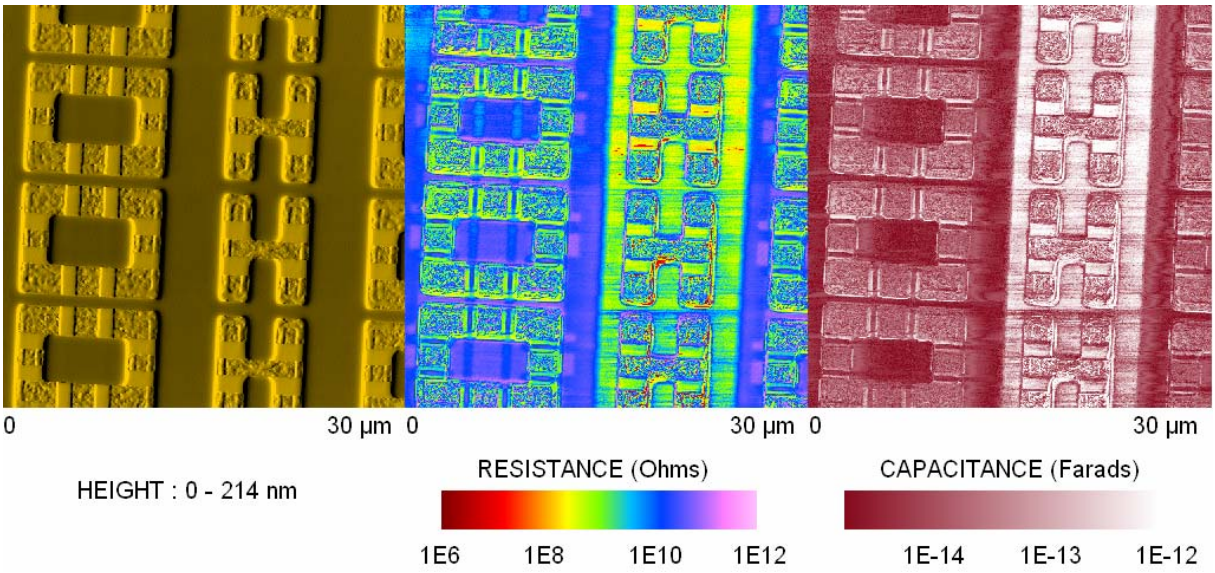

Figure 3 : *Triple H-R-C maps obtained on the SRAM test sample supplied with Veeco's SCM system. sensors. This result proves that the capacitance image can be as rich and detailed as the resistance one.*