Advances in Quantitative Impedance Measurement and Dopant Level Profiling Using Scanning Microwave Microscopy

Shijie Wu[1], Manuel Moertelmaier[2], Ferry Kienberger[2], and Hassan Tanbakuchi[3]

1 Agilent Technologies, Inc., Chandler, AZ
2 Agilent Technologies Austria GmbH, Measurement Research Lab, Gruberstrasse, Linz.
3 Agilent Technologies, Inc., Santa Rosa, CA
Shijie_wu@agilent.com

Abstract

Scanning microwave microscopy (SMM) is a recent development in SPM technique that combines the lateral resolution of AFM and the measurement precision of microwave analysis. It consists of an AFM interfaced with a vector network analyzer (VAN). In the reflection mode (S_{11} measurement), the measured complex reflection coefficient of the microwave from the contact point directly correlates to the impedance of the sample under test. A linear calibration procedure for SMM using a capacitance standard has been developed and used to measure the minute capacitance difference, such as that between decanethiol and octadecanthiol SAM layers[1,2]. However, the linear calibration procedure is limited to a small impedance range. A nonlinear calibration algorithm that works on all measurement objects has been developed recently [3]. The new algorithm is valid for the measurement of quantitative complex impedance, and has means to discriminate between lossy and capacitive components. Results from electromagnetic simulation of the complex impedance at the tip/sample interface using EMPro will be presented as well. The capability of measuring the capacitance of a doped structure directly poses a unique advantage for SMM over the existing scanning capacitance microscopy technique. A high throughput C-V mapping workflow, Scanning Sawtooth C-V Spectroscopy (SSCV), was also established. This allows for nanoscale mapping of C-V curves for materials science applications. Based on capacitance measurement, SMM can be used for doping structure characterization of semiconductor devices see Figure 1. Quantitative dopant concentration can be obtained by calibrating the measured capacitance, C, or dC/dV against known dopant structures such as that fabricated by IMEC.

References

[1] H. P. Huber, M. Moertelmaier, T. M. Wallis, C. J. Chiang, M. Hochleitner, A. Imtiaz, Y. J. Oh, K. Schilcher, M. Dieudonne, J. Smoliner,P. Hinterdorfer,S. J. Rosner, H. Tanbakuchi, P. Kabos, and F. Kienberger, Rev. Sci. Instrum. **81** (2010)113701

[2] Shijie Wu and Jing-Jiang Yu, Appl. Phys. Lett. **97** (2010)202902

[3] J. Hoffmann, M. Wollensack, M. Zeier, J Niegemann, Hans-Peter Huber
and F. Kienberger, 12th IEEE International Conference on Nanotechnology (IEEE- NANO)

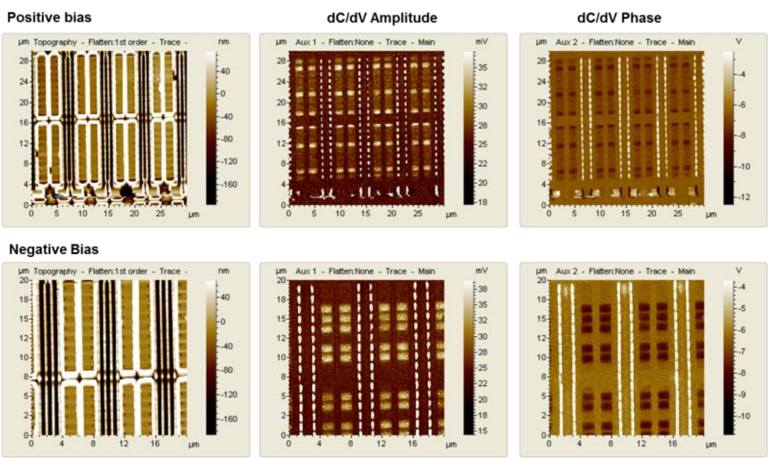

Figure 1. SMM imaging of eeprom cells with different DC bias applied