ELECTRIC FORCE MICROSCOPY OF INDIVIDUALLY CHARGED SEMICONDUCTOR NANOPARTICLES

Heinrich DIESINGER[1], Thierry MELIN[1], Sophie BARBET[1], Dominique DERESMES[1], Thierry BARON[2] and Didier STIEVENARD[1]

[1] Institut d'Electronique de Microélectronique et de Nanotechnologie, IEMN-CNRS UMR 8520, Avenue Poincaré, BP 60069, F-59652 Villeneuve d'Ascq Cedex, France
[2] Laboratoire des Technologies de la Microélectronique, LTM-CNRS, Leti, CEA-Grenoble, 17 rue des Martyrs, F-38054 Grenoble Cedex, France

Contact: heinrich.diesinger@isen.iemn.univ-lille1.fr

Charge injection experiments by electrostatic force microscopy (EFM) are performed on single semiconductor nanoparticles[1]. The amount of charge stored in particles of realistic shape is determined independently of the probe parameters via an analytical model[2].
EFM (Δf) data of nanoparticles therefore have to be decomposed into contributions resulting from dielectric and charge-dipole interaction. The weak dipole-dipole interaction[4] between the stored charge and its image dipole moment on the probe can also be identified.

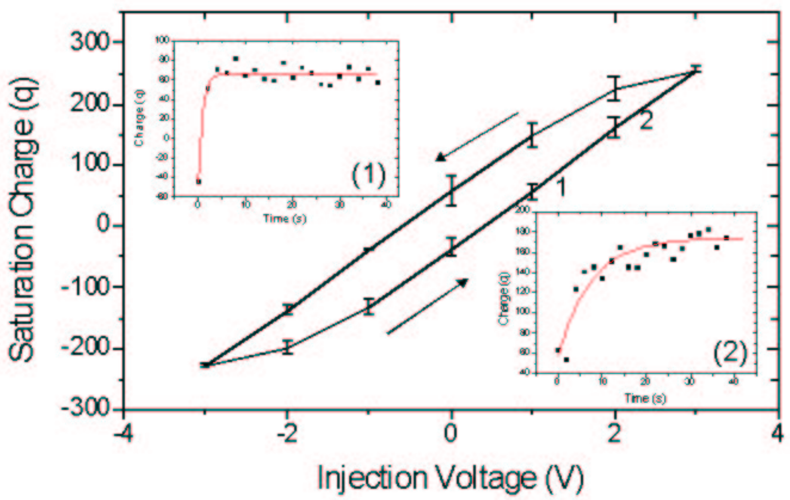

Fig. 1: Charge-voltage characteristic of a nanoparticle; the insets show the injected charge as a function of injection time at injection voltages V_{inj} = 1V (1) and V_{inj} = 2V (2); the adjustment of exponential approach functions yields the saturation charge Q_{sat} which is plotted as a function of injection voltage in the main figure.

The plot of equilibrium charge vs. injection voltage (fig. 1) shows an overall linear behavior with a hysteretic contribution[3].
To study the injection mechanism, time resolved charge measurements applying 1s injection time intervals are aquired (insets of fig. 1). From the approach of saturation regime, it is concluded that charge tunneling takes place across two inequal junctions. The hysteresis is attributed to a partial charge storage in interface states.
Complementary measurements on different samples prepared under ultrahigh vacuum further evidence the effect of interface states and bandgap on the hysteretic behavior.

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