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CHARACTERIZATION TECHNIQUES FOR NANO-ELECTRONICS, WITH EMPHASIS TO ELECTRON MICROSCOPY.

The role of the European Project ANNA

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Abstract. In the present and future CMOS technology, due to the ever shrinking geometries of the electronic devices, the availability of techniques capable of performing quantitative analyses of the relevant parameters (structural, chemical, mechanical) at a nanoscale is of a paramount importance. The influence of these features on the electrical performances of the nanodevices is a key issue for the nanoelectronics industry.

In the recent years, a significant progress has been made in this field by a number of techniques, such as X-ray diffraction, in particular with the advent of synchrotron sources, ion-microbeam based Rutherford backscattering and channeling spectrometry, and micro Raman spectrometry. In addition, secondary ion mass spectrometry (SIMS) has achieved an important role in the determination of the dopant depth profile in ultra-shallow junctions (USJs) in silicon.

However, the technique which features the ultimate spatial resolution (at the nanometer scale) is scanning transmission electron microscopy (STEM). In this presentation it will be reported on the nanoanalysis by STEM of two very important physical quantities which need to be controlled in the fabrication processes of nanodevices: the dopant profile in the USJs and the lattice strain that is generated in the Si electrically active regions of isolation structures by the different technological steps. The former quantity is investigated by the so-called Z-contrast high-angle annular dark field (HAADF-STEM) method, whereas the mechanical strain can be two-dimensionally mapped by the convergent beam electron diffraction (CBED-STEM) method. A spatial resolution lower than one nanometer and of a few nanometers can be achieved in the two cases, respectively.

To keep the pace with the scientific and technological progress an increasingly wide array of analytical techniques is necessary; their complementary role in the solution of present and future characterization problems must be exploited. Presently, however, European laboratories with high-level expertise in materials characterization still operate in a largely independent way; this adversely affects the competitivity of European science and industry at the international level.

For this reason the European Commission has started an Integrated Infrastructure Initiative (I3) in the sixth Framework Programme (now continuing in FP7) and funded a project called ANNA (2006-2010). This acronym stands for European Integrated **A**ctivity of Excellence and **N**etworking for **N**ano and Micro- Electronics **A**nalysis. The consortium includes 12 partners from 7 European countries and is coordinated by the Fondazione B.Kessler (FBK) in Trento (Italy); CNR-IMM is one of the 12 partners.

Aim of ANNA is the onset of strong, long-term collaboration among the partners, so to form an integrated multi-site analytical facility, able to offer to the European community a wide variety of top-level analytical expertise and services in the field of micro- and nano-electronics. They include X-ray diffraction and scattering, SIMS, electron microscopy,

medium-energy ion scattering, optical and electrical techniques. The project will be focused on three main activities: Networking (standardization of samples and methodologies, establishment of accredited reference laboratories), Transnational Access to laboratories located in the partners' premises to perform specific analytical experiments (an example is given by the two STEM methodologies discussed above) and Joint Research activity, which is targeted at the improvement and extension of the methodologies through a continuous instrumental and technical development. It is planned that the European joint analytical laboratory will continue its activity beyond the end of the project in 2010.