High Resolution Imaging and X-Ray Microanalysis in the FE-SEM

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The new generation of Field Emission Scanning Electron Microscope (FE-SEM) can perform high resolution imaging at incident electron beam energy below 1 keV. Images with resolution smaller than 2 nm are now guaranties by various manufacturers. Since imaging below 1 keV allows obtaining surface details of nanomaterials and reduces beam damage for sensitive materials, it is clear that electron microscopy is now entering in a new era. With FE-SEM that can operate in the 50 eV to 30 keV mode with many images modes like conventional bulk secondary electron (SE) or backscattered electron (BSE) imaging or new scanning transmission electron microscopy (STEM) imaging of transparent materials in bright field or dark field mode, the versatility of these microscopes is obvious. Also, if we keep in mind that we can also perform quantitative x-ray microanalysis with start of the art SDD EDS detectors and crystallographic characterization of materials with EBSD detectors, FE-SEM has a very bright future and its importance in science and technology will growth faster than ever because we have now microscopes that can deliver enough current with high spatial resolution to fully exploit the advantages of low voltage scanning electron microscopy as predicted by Von Ardenne as far as 1942.

This paper will present new results for the characterization of various nanomaterials obtained with the new Hitachi SU-8000 cold field FE-SEM recently acquired by the research group of Pr. Gauvin. This FE-SEM has 1 SE lower detector, 2 SE upper detectors with various modes of energy filtration, a five quadrant BSE detector, a STEM detector that works in bright field, an electron convertor that allows to use the SE lower detector for dark field STEM imaging, a 80 mm2 SDD EDS detector (Oxford Instrument) and the EBSD Nordlys II System (Oxford Instrument). The maximum probe current is 40 nA and this will allow performing quantitative x-ray microanalysis at low voltage. Also, this will allow acquiring EBSD maps at a faster time, eliminating the problems of drift current issues and flashing.

Figure 1 shows Au islands taken with the bright field STEM detector at 30 keV. Clearly, details with a resolution below 1 nm are clearly visible. Also, channelling effects in the propagation of transmitted electrons allow to image twins in the Au islands. These effects should be included in the modeling of these images. Figure 2 shows carbon nanotubes with tin palladium on their surface with a landing voltage of 500 V. It was possible to observe surface details with resolution close to the nanometer.

Impressive image details can therefore now be obtained with start of the art FE-SEM at low beam energy. Since the magnification of these FE-SEM can range between 10 times to 800,000 times, it is clear that the understanding of the microstructures of real materials and/or devices will be done extensively with this type of microscope with the combination of EDS and EBSD for quantitative characterization.

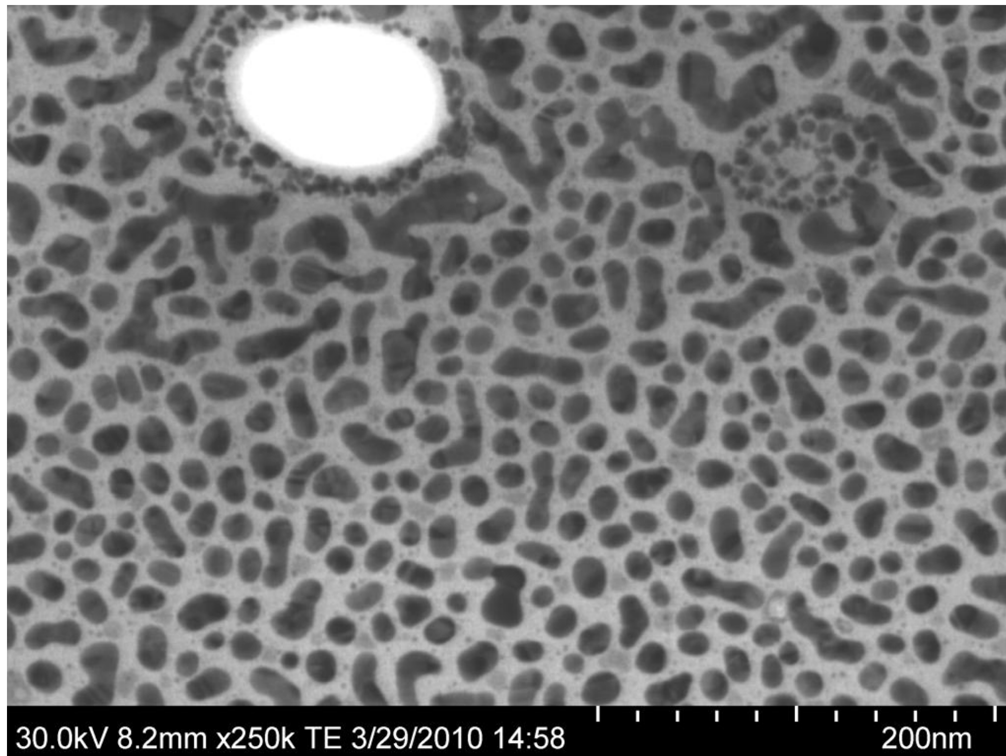

Figure 1: Transmitted electrons image of gold nanocoating showed the twins in Au nano-islands with an accelerating voltage of 30kV, at a magnification of 250,000 times.

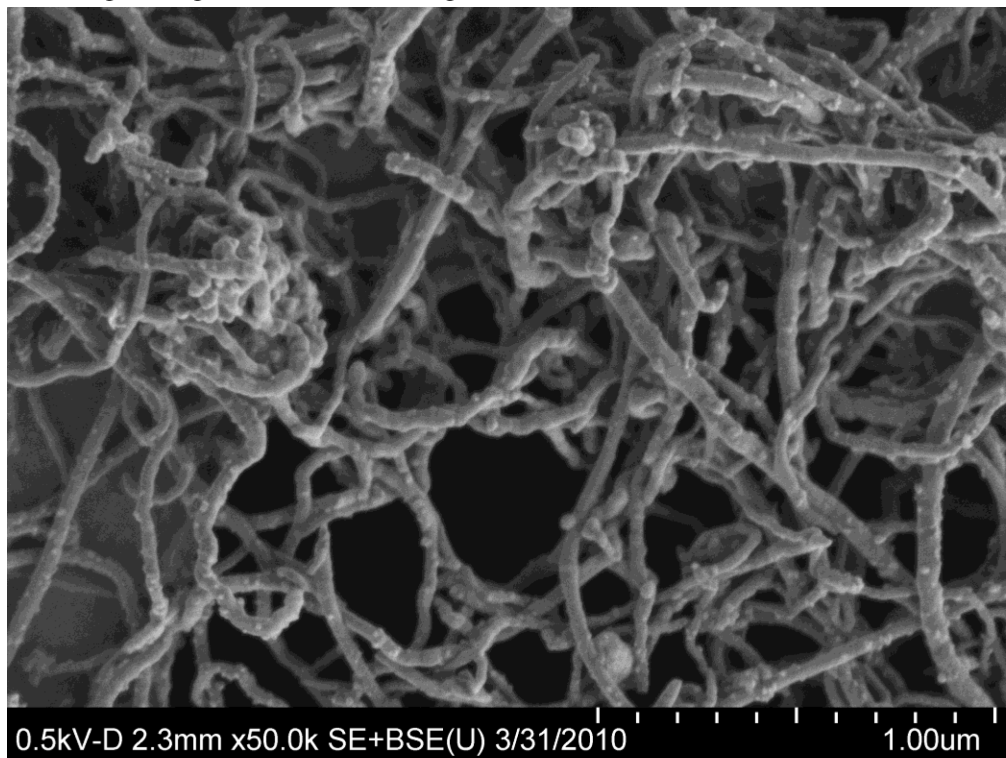

Figure 2: Upper detector image of carbon nanotubes with some tin-palladium nanoparticles obtained with a landing voltage of 500 V, at a magnification of 50,000 times showed extremely high surface details.