THIN FILM RESEARCH LABORATORY

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ÉCOLE POLYTECHNIQUE MONTRÉAL

Université de Montréal

Thin Film Research Laboratory

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EDITOR'S NOTE

In response to the interest expressed by industry, the GCM is proud to offer short courses in materials characterization, especially aimed at meeting industrial needs. These one-day short courses cover the theory of many analytical methods like Atomic Force Microscopy (AFM), XPS, SIMS, Auger, and they include applications taken from several industrial sectors. These short courses are given by competent professors of the GCM. Here are the two courses offered this Spring:

Atomic Force Microscopy for industry
29 April 2010, École Polytechnique, Montréal, Canada

Surface analysis for industry : the major spectroscopic techniques
21 April 2010, École Polytechnique, Montréal, Canada

You can register right now at www.gcmlab.ca/en/events.php

The short courses will be given in English.

We hope to see you there.

Jean-Sébastien Tassé, Business Development Manager - industry

MICROSCOPY : TO AFM OR TO SEM?

When a problem arises at the surface of materials, the first reflex is often to visually examine the problematic area. In many cases, the naked eye or an optical microscope will be sufficient. However, when the dimensions at stake are relatively small, of the micron or nanometer scale, one must use more advanced techniques like Scanning Electron Microscopes (SEM) or Atomic Force Microscopes (AFM). In this article, we explore the benefits and limitations of both techniques.

Overview of the working principles

A SEM creates an images of a sample by scanning the surface with a focused electron beam. The interaction between the sample and the electrons generate a signal that comprises many types of emissions like secondary electrons, X rays, backscattered electrons, etc. Most SEM utilize secondary electrons as the main signal.

We refer you the March newsletter (www.gcmlab.ca/en/newsletter.php) for an explanation of AFM working principle.

Spatial and depth resolution

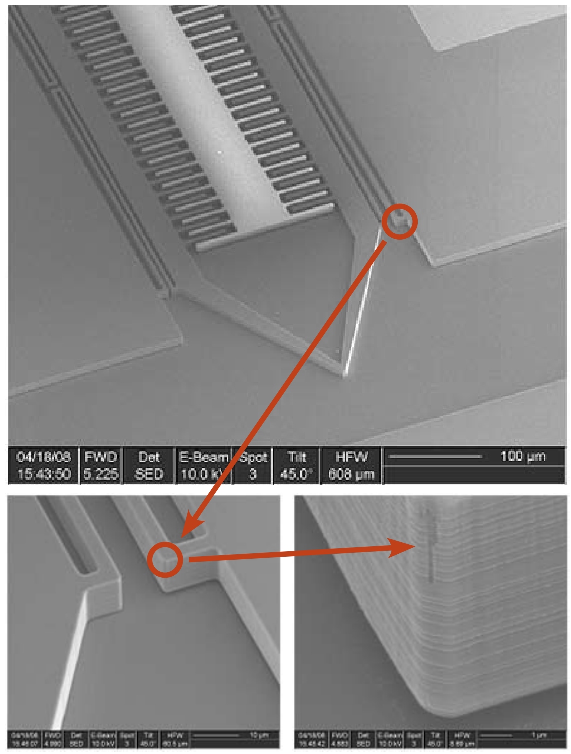
The most recent SEM and AFM both offer a very high resolution : a few nm for the SEM and 0.1 nm for the AFM. Although their lateral performances are similar, SEM and AFM differ in their way to treat vertical changes in topography. Indeed, SEM benefit from a depth of field of several microns, as long as there exists a direct angle of view between the source and the structure under study. The maximum depth that can be surveyed by AFM is limited by the tip vertical displacement, which is usually 5 ou 6 µm.

In spite of its high depth of field, SEM gives scant information on the vertical distance between two details on the surface. In some cases like observing a large hole in a sample, it is possible to get an idea of the tridimensional features by slightly tilting the sample. AFM, on the other hand, gives directly tridimensional information, a characteristic that is very useful for determining the depth of a trough or the height of a bump, within the resolution limits of the instrument.

Types of samples

The great strength of AFM resides in its capacity to image samples of all types : organics, inorganics, conductors, insulators, etc. Since AFM does not rely on conductivity, its response is not affected by the presence of a liquid. This characteristic makes it ideal for the analysis of hydrated samples in life sciences or in the area of polymers.

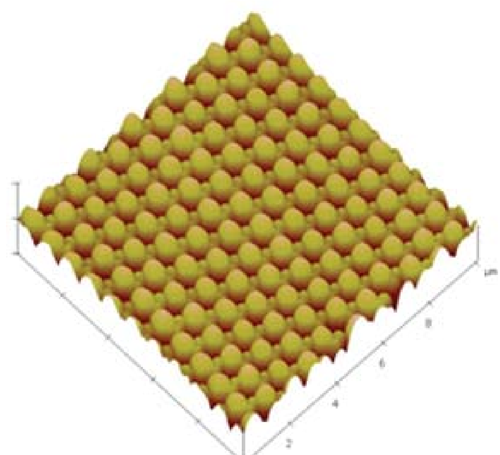
SEM being a vacuum technique, it is important to first assess the vacuum compatibility of any sample before observing it with a SEM. Both solid samples show a good vacuum compatibility, unless they degas at low pressure. Hydrated biomaterials are a particular case that requires the use of an environmental chamber. In another respect, SEM can analyse conductors, semiconductors or insulators. In the case of insulators, charging effects can reduce the signal-to-noise ratio and accordingly reduce the SEM resolution. Depending on the sample and resolution required, some strategies can be used to counteract these effects.



SEM image of a microstructure.
Microfabrication course, École Polytechnique, professor : Yves-Alain Peter.

Areas analysed

SEM is generally considered a more versatile instrument than AFM because its adjustable magnification (a few tens of times up to millions of times) can help to rapidly find the area of interest, while offering a great flexibility to observe finer details. As to the AFM, it can scan surfaces whose typical dimensions range from hundreds of nanometers to 100 µm x 100 µm.



AFM image of a bilayer of polysyrene microspheres.
Patricia Moraille, GCM.

Conclusion

Even though AFM and SEM are based on different principles, they share a number of common points: the two techniques make use of a scanning probe to form an image, they both offer equivalent lateral resolutions and they are generally non destructive. However, these methods are different in that AFM can measure in the three directions, while SEM is more limited. In addition, the two techniques operate in different environments, which leads to the fact that AFM does not encounter vacuum challenges (sample preparation, etc) and can image samples in liquids or in gas. In most cases, SEM and AFM are complementary and when they are used jointly, they provide more information on the surface than if they were used separately.

Service availability

Both AFM and SEM are available for your analyses in the GCM and its partner laboratories at École Polytechnique and Université de Montréal.