THIN FILM RESEARCH LABORATORY

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AFM VS SEM : THE ULTIMATE FIGHT!

In the April newsletter (http://www.gcmlab.ca/pdf/GCM_newsletter_no4.pdf), we have explained the working principles of Atomic Force Microscopy (AFM) and Scanning Electron Microscope (SEM) and we have discussed their strengths and weaknesses. This month, AFM and SEM engage in a fight involving the analysis of three different kinds of samples. Let the game begin!

1st round: imaging of a photonic crystal

In this first round, AFM and SEM are confronted with a two-dimensional photonic crystal made of silicon nitride on a silicon substrate. This structure was fabricated by electron beam lithography and Reactive Ion Etching (RIE).

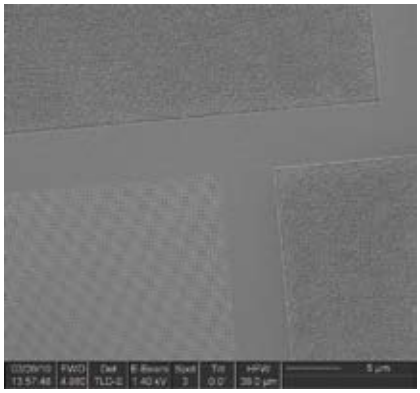

Figure 1: *SEM image of the spring arm that is used to hang the photonic crystal*

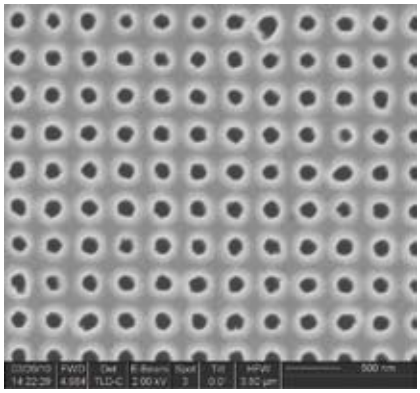

Figure 2: *SEM image of the photonic crystal (zoom of the lower left area of figure 1)*

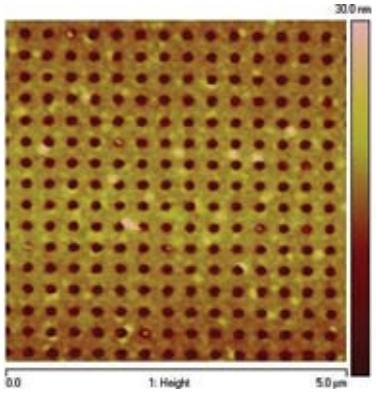

Figure 3: *5 µm x 5 µm AFM image of the photonic crystal*

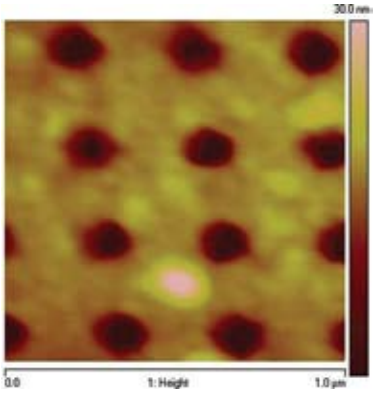

Figure 4: *1 µm x 1 µm AFM image of the photonic crystal*

In this first round, both SEM and AFM demonstrate their ability to resolve very fine details, such as the slight non-circular shape of the holes. However, SEM differentiates itself from AFM by its capacity to rapidly magnify the area of interest.

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2nd round: imaging of an AFM calibration grid

This second round brings us on a ring where AFM is seen as favorite: the imaging of a silicon grid that serves to calibrate AFM in the X, Y and Z axes. The grid holes have a depth of 200 nm.

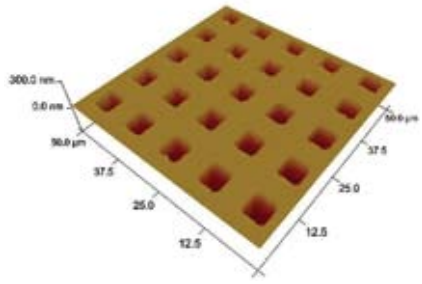

Figure 5: AFM image of the calibration grid

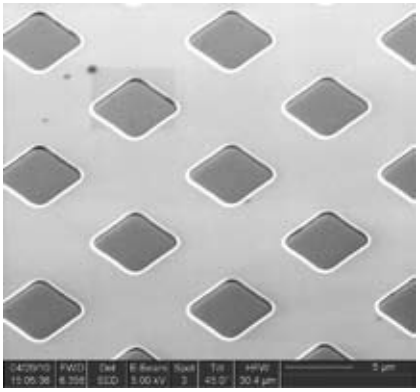

Figure 6: SEM image of the grid taken at a 45 degrees tilt

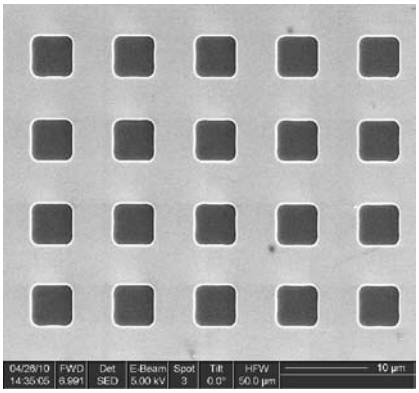

Figure 7: SEM image of the grid, perpendicular view

The punters who have bet on the AFM were right: AFM dominated this second round thanks to its capacity to image tridimensional structures, whereas SEM gives scant information on the sample topography. However, both methods showed a great performance in analyzing the lateral dimensions of the holes. Analytical tools can also evaluate the depth of the structures by compensating for the observation angle.

3rd round: imaging of a plasmionic nanostructure

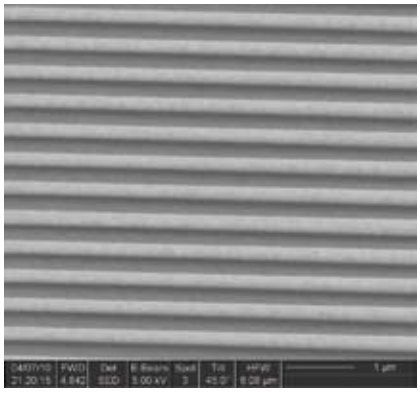

Figure 8: SEM image of the nanostructure

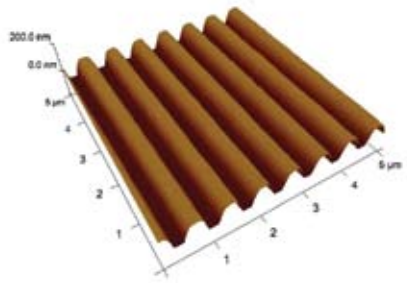

Figure 9: AFM image of the nanostructure

The third and last round involves the analysis of a nanostructure consisting of 300 nm-spaced gold barriers laid out in a pattern that takes advantage of surface plasmon resonance. The potential applications for this structure are very broad: amplification of spectroscopic signals, new types of lenses, optical filters, etc.

Like in the second round, the AFM tridimensional capabilities demonstrate a ruthless efficiency in this third round. We emphasize in figure 9 the sharp spatial and depth resolution of the AFM.

Final score

This was an exciting fight that ended in a draw. AFM showed its strength to image vertical topographies whereas SEM offers a visual portrayal of the sample and a great flexibility for quick magnification. Both AFM and SEM have their own characteristics that make them more complementary techniques than competitive ones.

Analysis by AFM and MEB

The GCM and its partner laboratories offer AFM and SEM analytical services for all kinds of samples.

References and acknowledgements

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