Letters to the Editor

Resolution And Resolving Power

In our November 2000 issue, Ron Anderson (IBM Corporation) provided an article relating to the understanding of SEM resolution. Jeff Rosner (Agilent Laboratories), as follows, has provided several observations to this article. And a reply from Ron Anderson to these observations also follows

Dear Mr. Editor,

Ron made some excellent points about understanding SEM "resolution" in the November 2000 issue of Microscopy Today. He effectively pointed out that real samples have many non-ideal features (topography, varying atomic number, contamination by different materials, sites for charging, etc.) that conspire to reduce the ability to resolve features at the limits of the microscope operation. I agree entirely.

He then goes on to suggest that we take one's "bread-and-butter" samples to each manufacturer and compare the resulting images as a strategy for comparing microscopes. This can be a successful strategy only if those samples are EXTREMELY well-controlled. The problem here is that, a) the selected area for image comparison will become increasingly damaged/contaminated with each subsequent exposure to the electron microscope and, b) using different areas is an unacceptable approach because it becomes a comparison of ideality of differing sample regions. Very little information about the "microscope performance" is produced from this exercise unless one is comparing, say, an older LaB6 instrument with a modern field emission instrument. This could show that in one case microscope performance limits the image quality and in the other case, sample condition limits the image quality.

If one is comparing a variety of "comparable" instruments, that is, instruments competing in the same price/performance market space, the image quality differences are going to be subtle. It is probably important to compare issues like detector placement and detection efficiency by using the type of samples that one is going to be using, but operator dependent issues like detector gain, electronic contrast/brightness settings, etc., will be VERY important. This, however, is only one parameter.

Examples of other important parameters:

- Ability of the detection scheme to image large topographies (*e.g.*, bottoms of deep holes)
- Charge suppression (Try imaging a ground glass plate and controlling flare and the high points)
- Test backscatter detection schemes for ability to get topography free atomic number contrast, with a thin film multilayer in cross-section (perhaps etch one sample to provide topography)
- Evaluate the 'user interface' of the microscope and the ability to integrate with your laboratories information infrastructure. A microscope that produces quality results at low productivity can be less than a perfect asset.
- ESEMs have a whole host of other parameters that I am less qualified to comment on.
- If you are in a research lab, evaluate the future expandability/upgradability of the microscope...can novel detectors be added, automatic stage control, multiple EDS/calorimetry detectors, etc.
- If you are in a production environment, how robust is the instrument? Can you crash the stage into the detectors or the pole piece?
- This is just the short list...I would suggest that each potential purchaser spend a substantial amount of time thinking about what is important to them!

Buying a new microscope is a decision that most labs will

have to live with for 5-20 years!! It should be made carefully and as quantitatively as possible. With respect to resolution, the Au/C sample is still a useful comparison...what I always like to see is how fast a skilled operator (at a demo) can walk up to a machine and generate a "proof of performance" with their own ideal sample. This tells one a lot about the usable machine-dominated resolution capability.

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Response from Ron Anderson:

Dear Jeff,

I would respond by saying that my point was that resolving power and resolution are two different things in an SEM. Resolving power is measured using gold dots on a carbon grid. Resolution is different for each SEM micrograph taken as a function of the list of items you mention, and very rarely comes close to the instrument's resolving power. I wish salesmen would make this point clearly to avoid the frustration of users who can't understand why they are seeing 10 nm resolution in what supposedly is a 1 nm "resolution" instrument. Actually, it would be far better if sales and technical representatives of the instrument makers would explain the differences between "real" samples and gold dots on a carbon film and then instruct the user on the many steps that can takes to improve the resolution of each micrograph.

Now, seeing as you raised the point of taking "bread-and-butter" samples to evaluate an instrument: I hope no one else thought that I was suggesting using the "same" sample, and sample area, with each manufacturer. Of course, that sample will become contaminated and damaged! We take "identical" samples for evaluating both SEMs and TEMs. I don't see where that is a big deal. We're talking freshly-prepared, bread-and-butter samples, that have been produced for years in our lab by very experienced people. I appreciate the points you make regarding ideality of surfaces, but I do not feel that any differences that might arguably exist between "good" samples would influence the evaluation of an instrument.

Regarding your list of parameters for evaluating the subtle differences between comparable instruments: nice job. I would agree with your implied point that the list can be divided between "microscope performance issues" and "operator dependant or user interface issues." Inasmuch as we are looking to buy an instrument, not hire an operator, we place greater emphasis on the former. The only fair way to evaluate microscope performance issues at a vendor's demonstration facility is to remove you, as the operator, from the evaluation. Our presumption is that the vendor's instrument demonstrator is as skilled as one can become using that particular instrument. Our approach is to make a list (beforehand and the same at each demonstration) of the technical features you want demonstrated: resolving power, resolution on the B&B samples, low/high voltage, whatever, ... "and" let the demonstrator run the instrument and take the pictures with you looking over her shoulder. Don't touch the thing or say anything to slow her down until the required comparison pictures are taken. THEN, you can sit down and try and get a sense of the user interface parameters.

Have each operator take the same pictures of the same features on fresh samples at each manufacturer. Make high quality copies of each picture before anyone in your lab sees them. Cut the microscope manufacturer logos, micron markers, etc., off one set after coding the pictures on their backs as to where they come from. Scramble the pictures on a conference table and call in a skilled microscopist (who might recognize different micron marker styles), a professional competent in the field, and your 10-year old from home. Ask them to sort the pictures, best to worst, in each category. It's been our experience that the same manufacturer will be on, or close to, best in every case. Factor in your user interface results and you've got your scope! In my humble opinion. ■

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