LVEM 5 User Profile: Dr. Gyula Faigel

Dr. Gyula Faigel is an expert in X-ray physics and leads a laboratory that has evolved from a small team into a comprehensive research environment, featuring a chemistry unit for sample preparation and a group focused on nucleation theory. The X-ray section comprises four researchers. They routinely use advanced large-scale facilities such as synchrotrons and X-ray Free Electron Lasers (XFEL). The LVEM 5 was introduced into the laboratory as a complementary tool for routine morphological characterization of nanostructured materials that cannot be reliably described by X-ray techniques alone.

Can you please tell our readers a little bit about yourself?

I am an expert in X-ray physics. I started building my laboratory with just two people, and it quickly grew to about 20. The lab now includes a chemistry department that prepares samples and a section on nucleation theory. In the X-ray section, there are four people. In my field, we routinely work with synchrotrons and XFELs, which represent the most advanced X-ray sources. The research done at these sources is at the forefront of many scientific areas.

Why did you choose to purchase an LVEM instrument?

We needed basic sample characterization because, without good characterization, it is difficult to tackle problems in materials science. While we used X-ray and powder diffraction for atomic-resolution analysis, we were also working on materials such as nanotubes, which lack a well-defined periodic structure and therefore cannot be easily characterized by X-ray methods. We needed an instrument capable of providing morphological information at the nanometer scale.

The LVEM 5 appeared to be a very good compromise between optical microscopy and higher-resolution electron microscopy. It represented a significant improvement over our old scanning electron microscope, which was from 1972 and had a resolution of approximately 100 nanometers. The relatively low cost compared to a conventional transmission electron microscope, combined with the reduced radiation damage at low energy – critical for sensitive materials such as graphene and nanotubes – was a key factor. Day-to-day access was also crucial, as relying on shared high-energy transmission microscopes at other institutes made routine characterization difficult.

What are your favorite things about the instrument, now that you've owned it for some time?

I appreciate that it is a very clever instrument. It can be used effectively as a scanning electron microscope, even though that is not its primary purpose. The combination of three modes – SEM, TEM, and diffraction – in a single instrument is beneficial, even if not all modes are applicable in every case. It enables us to establish a solid understanding of the sample at an early stage, which is crucial for fast progress, and helps produce high-quality publications.

Can you briefly describe your recent work and how the LVEM helped you?

Most of the work with the LVEM 5 is carried out by two colleagues, primarily by Áron Pekker. One of our first applications was the characterization of AFM tips used in near-field optical microscopy, to ensure that the tips were neither contaminated nor blunt, as this would compromise the measurements.

We also studied nanotubes filled with nickel-containing compounds. Using the transmission mode, we examined whether decomposition occurred and whether nickel atoms formed clusters inside the nanotubes.

Another project involved a hybrid perovskite system added to nanotubes. Using the scanning mode, we investigated how the material was organized – whether it crystallized or remained amorphous – and how it was distributed.

We are currently working on barium carbonate systems for the nucleation theory group. The LVEM is used to characterize the different crystalline forms that emerge depending on sample preparation, providing input for theoretical modeling. In this project, we mainly use the SEM mode.

What are other ways you utilize the LVEM in your research?

We have also utilized the diffraction mode on graphene, which was of particular interest to me as a specialist in diffraction. While the expected diffraction spots were observed, it is generally difficult to find systems other than graphene that are thin enough to produce clear electron diffraction patterns. Overall, the instrument is used predominantly in scanning electron microscopy mode.

Where did you decide to place the instrument?

The instrument is located in a dedicated microscopy laboratory that also houses the atomic force microscope and the near-field infrared microscope.

How hard was site prep?

The site preparation was straightforward. The instrument is compact, and the laboratory was already designed to be a low-noise, low-vibration environment, meeting the AFM's requirements, so no special adjustments were necessary.

How many users in your team are trained on the instrument?

Approximately ten people use the instrument. Because sample preparation and handling are not entirely trivial, their use is supervised by Áron Pekker and Gábor Bortel.

How hard is it to learn the technique?

Imaging itself is relatively simple. The main difficulty lies in working with very small samples and fixing them carefully onto the sample holder. For scanning electron microscopy, the sample must be inserted upside down, which adds a layer of complexity.

What would you like to say to someone considering purchasing an LVEM?

It is a well-designed experimental setup. If it fits their needs, I would recommend it. It is a very clever instrument.

How did you raise the funding for the purchase?

The instrument was financed through external funding as part of a larger package, totaling approximately 160 million HUF at the time, provided by a Hungarian development agency. This took place during the period when, unfortunately, we were separating from the Hungarian Academy of Sciences.

Do you have plans for additional projects utilizing the LVEM?

The ongoing work on barium carbonate for the nucleation theory group is expected to continue for approximately another year. It is anticipated to result in one or two publications, likely based on an MSc thesis. Further continuation will depend on whether modifications to the surface layer can yield optically interesting properties. We also plan to continue our work on carbon nanotube systems, using the LVEM.