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MSA Focused Interest Groups: Atom Probe Field Ion Microscopy and Focused Ion Beam Microscopy

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In 2002, the Microscopy Society of America (MSA) launched a new initiative: Focused Interest Groups (FIGs). The FIGs were designed to promote the science of microscopy and microanalysis, increase participation at the annual Microscopy and Microanalysis (M&M) meeting, enhance collaboration and idea-sharing between microscopy and microanalysis disciplines, and increase interactions between microscopists at all career stages. In the last 20 years, several FIGs have exceeded this initial charter by formulating shared databases, developing important field standards, hosting external workshops and tutorials, and organizing Pre-Meeting Congresses (PMCs), Sunday Short Courses, Symposia, and social events at the annual M&M meeting. Because these FIGs have proven to be powerful networking resources and helpful career accelerators, this is the beginning of a series of articles designed to introduce you to the different FIGs and let you know how you can get involved, too.

Two of the oldest and most interconnected FIGs are the Atom Probe Field Ion Microscopy (APFIM) FIG, which is currently led by Daniel Perea, and the Focused Ion Beam (FIB) FIG, which is currently led by Josh Sugar. These two communities are closely affiliated because most atom probe tomography (APT) experiments require needle-shaped samples, prepared using a FIB instrument. Both FIGs are individually and collaboratively responsible for continuously investigating new techniques and informing members about cutting-edge hardware and software developments that are impacting research groups within these scientific disciplines.

Atom Probe Field Ion Microscopy (APFIM) FIG

The APFIM FIG (Communities - Atom Probe Focused Interest Group (AP FIG) | Microscopy Society of America) explores the frontiers of both APT and field ion microscopy (FIM) for materials characterization. Their primary goal is to provide a forum for the exchange and discussion of information and ideas relevant to the scientific advancement and impact of the field and to increase general awareness: for example, by expanding the application of APT to new material classes or by promoting the adoption of standards for terminology and data analysis within the community.

The value of these two pivotal techniques can be traced back to their historical origins. The FIM was invented by the physicist Edwin Müller in 1951, and it allowed him to photograph the surface of metal crystals at near-atomic levels. In 1967, Müller teamed up with John Panitz and S. Brooks McLane to demonstrate the 1-D atom probe, which enabled viewing of a single atom. Building on this landmark discovery, a series of advances made collectively by several research groups around the world evolved the 1-D atom probe into a 3-D atom probe, and eventually into the modern APT instruments and techniques we use today.

When the APFIM FIG was formed in 2002, novel laboratory-built APT instruments were just starting to become commercially available and featured an advanced counter electrode design with an integrated FIM system. Over the last 20 years, commercial availability has significantly increased the number of groups adopting these techniques and enabled the exploration of multiple materials classes, including ferrous and non-ferrous alloys, semiconductors, photovoltaics, ceramics, geological materials, biological materials, battery materials, and small molecule organics.

The FIG has grown to ~30 members, including a diverse and international body of researchers representing universities, national laboratories, and industry. The benefit of this group is that it allows field pioneers to share ideas, articulate new visions, and address ongoing challenges. For example, in 2002, the nascent commercial hardware and still-emergent data analytic techniques inspired the group to establish numerous round-robin experiments, discuss best practice data analysis, and exchange samples to establish comparisons between various labs around the world. While these are still areas of great interest, as the field has become more widely established, the APFIM FIG has also recently begun to take a more active role in organizing APT-based symposia at the annual M&M meeting, including PMC events and workshops that have helped to establish standards, such as unified protocols for APT sample preparation, data collection, reconstruction generation, evaluation and analysis, and the reporting of APT results. These PMCs are organized every 2–3 years and are hosted by the FIG as a separate 1-day workshop, just before the annual M&M meeting. The first fruits of these efforts are being realized as a broad consensus of definitions for ISO terminology specific to APT and FIM are being developed.

Looking ahead, the continued growth within the APT and FIM communities is exciting, and focused groups like the APFIM FIG help facilitate that advancement. The recent

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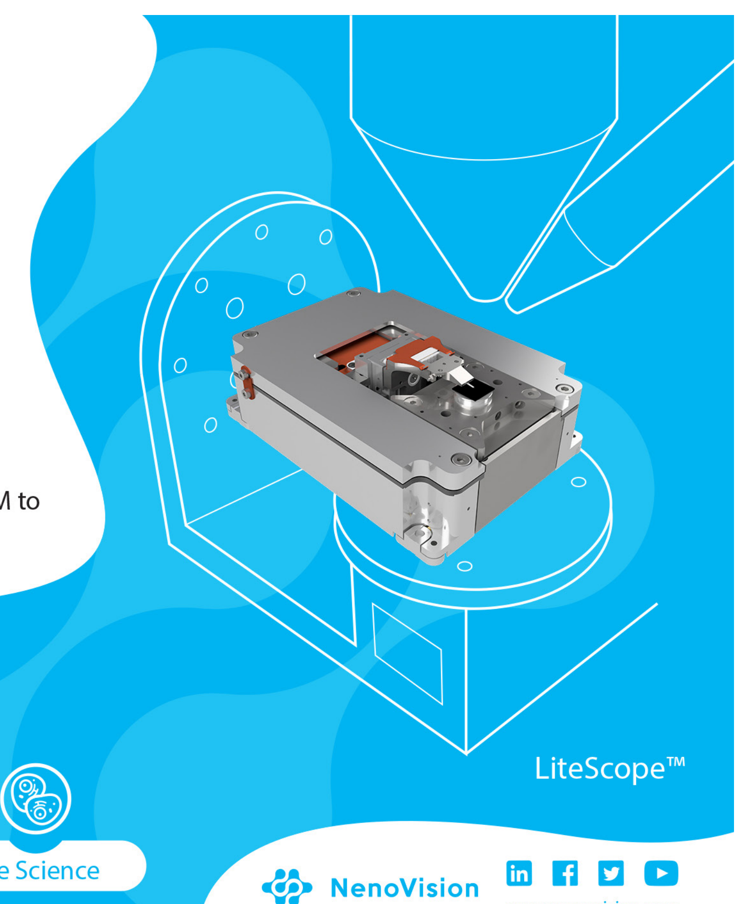

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Figure 1: APFIM FIG Annual Business Luncheon at the 2015 M&M meeting in Portland, OR.

explosion in both hardware and software development, including the exploration of shorter laser wavelengths that potentially push into photoionization regimes, the development of next-generation higher efficiency detectors, the demonstration of environmentally protected specimen transfer, and the development of machine learning-enabled automated data collection algorithms and advanced data visualization and extraction, is increasing participation in this community. As the field expands, the APFIM FIG will continue to serve as a nexus for discussion, bringing together researchers in disparate areas to share their vision and discuss ideas for further advancing the field. In doing so, the APFIM FIG will continue to facilitate networking between those who are new to the technique and seasoned APT researchers.

Focused Ion Beam (FIB) FIG

The FIB FIG (Communities - Focused Ion Beam | Microscopy Society of America) provides a platform for disseminating FIB-relevant information, sharing ideas, and generating enthusiasm about emergent FIB techniques. The FIB FIG's mission is to promote the ongoing development of FIB technology and facilitate networking between professionals working with multiple charged particle beam systems.

The members have expertise with gallium, plasma, and helium ion species, and discussions frequently range across scientific disciplines—from materials science to life sciences. In part, because of these discussions, many of the FIB FIG members are early adopters of new techniques, like cryogenic and laser FIB.

Figure 2: Logo for the Focused Ion Beam FIG.

FIB FIG's activities include a biennial PMC and the "Advances in Focused Ion Beam Technology" symposium, which is hosted at the annual M&M meeting. In 2020, the FIB FIG members began to examine their impact on the community outside of M&M. They discovered that, while FIB FIG members network with each other, the current demographic of the FIB FIG community skews toward seasoned ion beam veterans. To balance this demographic, FIB FIG members are taking steps to encourage participation from the next generation of technologists, who will have the opportunity to explore new ideas, practice their presentation skills in a friendly environment, and benefit from the career networking opportunities represented by this group. To that end, in 2022, the FIB FIG group began hosting informal virtual quarterly meetings, which serve as a safe space in which participants may ask any kind of question, to share triumphs, and to brainstorm responses to ongoing challenges. For example, in January, Josh Sugar (Sandia National Laboratory) and Suzy Vitale (Carnegie Mellon University) hosted a meeting titled "FIB Fails." In May, Aleksander Mosberg (SuperSTEM) led an inquiry on alternative methods of FIB control. These quarterly meetings are open to all FIB enthusiasts, regardless of their MSA or FIG membership status. Anyone who is interested should contact the current FIB FIG Chair for details on this quarterly meeting.

To further support education and encourage live discussion, the FIB FIG group is also actively building an interactive web presence. The first outreach platform will be a WordPress Wiki-style website fibfig.com, where everyone can learn more about FIB theory and techniques. The site's subdomains each host live discussions on key topics, including liquid metal ion sources (LMIS) such as gallium, gas field ion sources (GFIS) such as helium and neon, and plasma sources. The second outreach platform is a low-traffic Slack channel, which serves as a landing site for idea exchanges, community projects, conference organization, resource coordination, and a Q&A forum for the whole community of FIB experts.

In the long term, the FIB FIG will create a framework through which current and prospective members can easily network, adding their voices to ongoing projects like the PMCs, M&M symposia, quarterly meetings, and web forums. All these venues enable the FIB FIG membership to support a diverse dialogue and accelerate the evolution of a broad range of cutting-edge microscopy techniques, including TEM lamella, 3D FIB-tomograms, lithography, nanomachining, segmentation of collected data, and low-temperature techniques.

FIG Formation and Membership

At this time, there are 12 established FIGs within the MSA community, but a petition to create a new FIG can be submitted at the MSA Summer Council Meeting, during the annual M&M meeting in early August. Anyone who is interested in forming a FIG can contact the current FIG Chair for details (see the microscopy.org website under Communities → Focused Interest Groups).

Joining a FIG is both inexpensive and simple. Just visit the microscopy.org website, look for the Members Portal tab, and register in the FIG Store. The membership fees for every FIG are $15 per year, which pays for catered lunches at the FIG's annual business meeting, which is open to all FIG members and held during the annual M&M meeting. FIG dues may also support website creation/maintenance, social events during the annual M&M meetings, and workshops/meetings held outside of the annual M&M meetings. *Students who are members of the MSA are provided with one free registration to any FIG*, which they can collect online in the FIG Store. MSA members are welcome to join multiple FIGs and are encouraged to broadly participate in symposium organization and PMC planning activities. MSA is committed to strengthening our community engagement, and the FIG communities facilitate these dedicated efforts toward deep discussions across scientific disciplines focused on state-of-the-art microscopy and microanalysis.

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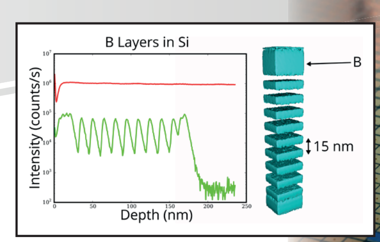

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