Securing Funding for Research Microscopes Through the NSF MRI Program

Learning from the Recent Success of Scientists at the University of Vermont

ZEISS

Seeing beyond

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The National Science Foundation's (NSF) Major Research Instrumentation (MRI) Program provides funding awards for the purchase of capital equipment in a variety of research fields[1]. It represents the largest annually recurring public funding for scientists and engineers with the total pool of funds ranging from $80 to $100 million[2]. Over the past five years, close to 200 microscope awards have been funded, totaling over $100 million. Of that total, about $65 million has been dedicated to microscopy in the fields of physical sciences, engineering, and geosciences[3]. A research consortium at UVM applied and received funding for a new scanning electron microscope which has proved to be a boon for materials science research and the local community. Much can be gleaned from the UVM consortium's application process and perseverance, providing useful lessons for other university researchers pursuing MRI funding.

Grant Application Focused on Rigorous Science and Partnership

The UVM consortium, led by Assistant Professor Matthew White, applied for a Scanning Electron Microscope (SEM) for several years and were ultimately successful upon their third application. White and the other investigators on the team – Professor and Chemistry Department Chair Christopher Landry, Professor Randall Headrick, Associate Professor Laura Webb, and Professor and Acting Chair of Mechanical Engineering Frederic Sansoz – had a wide variety of needs to be filled by the desired instrument as their research cut across many scientific disciplines. While numerous instruments were considered early in the project's evaluation phase, ultimately the team landed on the ZEISS offering for the best combination of technical features and service commitment to fit the university's needs.

The team notes that the MRI is a particularly challenging grant application, where finding and presenting truly unique angles make the difference between rejection or success. The instrument needs to simultaneously support cutting-edge scientific research and serve a large number of diverse users, which are necessary and challenging requirements to reflect in the grant application. All ideas in the grant application must be presented effectively and concisely so that a reviewer unfamiliar with the field can understand the goals. In the event a project does not get funded initially, which occurred at UVM, the research team receives constructive feedback which must be rigorously used to refine and improve the application for the following year, a process for which the UVM team expressed their gratitude.

A strong application to NSF's MRI program is well-organized and succinct. The UVM consortium decided to summarize the instrument's intended usage by theme due to space constraints. While the instrument may be used by upwards of 50 people, the 15 major projects at UVM were distilled into three themes: geological and earth science, materials chemistry, and

thin films and devices. From the chemistry department, intended uses included imaging of electrodeposited nanostructures, nanoporous materials, and collaborative work with researchers at SUNY Plattsburg on cellular crystals. The thin films and devices projects were focused on nanomaterials applications from solar cells to organic semiconductors, metallic films for devices such as electrodes, and optical filters. A local Vermont company, Omega Optical, serves as an industrial partner for this portion of the research.

Thus far, the team has been pleased with the instrument's performance. The UVM team's grant application was accepted in the summer of 2018 and the award was made in the fall of that year, after which the group launched a competitive bid process ultimately leading to the June 2019 installation of the SEM. ZEISS' reputation for superior customer service helped the team select this instrument. (For one minor issue, a service engineer was able to walk a researcher through the process to solve it over the phone, which evidences the intuitive aspect of the SEM's design.) Operator training has gone smoothly and the system has performed nearly flawlessly thus far, receiving heavy use from the research teams since point of installation.

Figure 1 *ZEISS Sigma SEM*

Diverse Microscope Use Crosses Disciplines

The research team chose the ZEISS Sigma SEM for its technical performance and support available to the research team. The team required the performance of a field emission source, and the

1. *https://www.zeiss.com/microscopy/us/local/nsf-funding.html*
2. *https://www.zeiss.com/content/dam/Microscopy/us/download/nsf-funding-infographic.jpg*
3. *https://www.zeiss.com/content/dam/Microscopy/us/download/nsf-funding-infographic.jpg*

instrument provided excellent resolution and material contrast with gentle imaging interactions for beam-sensitive samples. Low-voltage operation allows for topographic, compositional, and crystallographic characterization of samples at a spatial resolution down to 1.2 nm[4]. In addition, low kV combined with Sigma's variable-pressure range are used for non-conductive soft and delicate samples. Overall, the team ended up configuring the Sigma SEM with secondary electron, five-segment back-scatter electron, electron backscatter diffraction (EBSD), and energy dispersive spectroscopy (EDS) detectors.

The physics application of the instrument, led by Prof. White, explores material physics for low-cost and high-performance photovoltaics. His research interests include nonlinear processes for optoelectronic devices and exploring photovoltaic materials with expertise in hybrid and organic photovoltaic devices[5].

Prof. Webb's research focuses on radiometric dating so that she and her students can understand how rocks, minerals, and regions evolve. Webb directs the 40Ar/39Ar geochronology laboratory where the use of microscopy features like EBSD, X-ray EDS, and others unveil geological information such as superficial microstructure, component analysis, and crystal structure[6]. The instrument's low-vacuum mode provides the added benefit of viewing samples without the need for applying a conductive coating.

The ZEISS instrument is currently the only SEM located in Vermont and as such is supporting a range of regional activity. As described in their proposal to the NSF, the team collaborates with

ECHO, the Leahy Center for Lake Champlain[7], a local marine science center.

In the summer of 2019, White hosted his annual organic optoelectronics workshop in which high school students spent two days using the SEM to image their own objects, including one who brought anti-counterfeiting microlens paper garnered via a parent's workplace. The SEM has also enabled White to develop a course titled The Fundamentals of Microstructure and SEM Surface Analysis for both undergraduate and graduate-level students. Additionally, in January 2020, UVM hosted 15 students from a science camp for a tour of the instrument and demonstrated imaging of familiar items such as peacock feathers, insects, and more.

Researcher Success with MRI-Awarded SEM Instrument

After iterating and improving upon their application through two unsuccessful submissions, the UVM research team persevered and has found great success with the NSF MRI-awarded ZEISS Sigma SEM. The wide-ranging needs of this research consortium are being addressed as they work on projects spanning physics, chemistry, engineering, materials science and geology for the analysis, identification, and characterization of nano and micro-scale structures. The SEM enables multi-university partnership and community engagement such that students from high school through graduate-level are learning on state-of-the-art technology, and local museums and classrooms can perform live experiments and demonstrations.

4. https://www.nsf.gov/awardsearch/showAward?AWD_ID=1828371&HistoricalAwards=false
5. https://www.uvm.edu/cas/physics/profiles/matthew-white
6. https://link-springer-com.resources.library.brandeis.edu/article/10.1007/s11430-015-5172-9
7. https://www.echovermont.org/

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