

Using a Tabletop Scanning Electron Microscope as an Outreach Tool to Engage the Public With Cutting-edge Research

Felix Lu^{1,2}, Anne Lynn Gillian-Daniel², Jerry Hunter^{2,3}, Nicholas Abbott^{2,4}

¹ University of Wisconsin-Madison, Dept. of ECE, Madison, WI, USA.

² University of Wisconsin-Madison, Materials Research Science and Engineering Center (MRSEC), Madison, WI, USA.

³ University of Wisconsin-Madison, College of Engineering, Madison, WI, USA.

⁴ University of Wisconsin-Madison, College of Engineering Dept. of Chemical and Biological Engineering, Madison, WI, USA.

Engaging K-12 students and public audiences with hands-on, engaging, research-inspired educational experiences is a fundamental goal of the University of Wisconsin- Madison (UW-Madison). To further this mission the NSF-funded UW Materials Research Science and Engineering Center (UW-MRSEC), the UW College of Engineering (CoE) and Hitachi collaborated to bring a TM-3000 tabletop Scanning Electron Microscope (SEM, Figure 1) into the UW CoE instrument facilities. The SEM is used as a popular outreach tool for attracting and introducing K-12 students, undergraduates, members of the public, and industry professionals to both the cutting edge research and the instrumentation facilities within the UW CoE. The SEM was purchased by the MRSEC and the CoE in 2013 for outreach events and use in CoE undergraduate courses. In 2015, an energy dispersive spectrometer (EDS) unit was added to the SEM through a collaboration with Thermo Fisher Scientific. This EDS unit allows elemental identification mapping of samples and was designed to work with the Hitachi SEM software. The TM-3000 SEM, while heavy for one person (at ~140 lbs) for the main unit, can be transported in a large vehicle truck (ex. a minivan or hatchback), plugged into a standard 3-prong outlet, is surprisingly robust to all the movement, and audience members as young as 10 years of age can easily obtain an image in >15 minutes through the user-friendly interface so it is ideal for public outreach events in many different settings. The SEM has been used in multiple outreach events on the UW-Madison campus to introduce public audiences to fundamental Science, Technology, Engineering, and Math (STEM) concepts and has been loaned out to regional schools so that their faculty, students, and community members can use it on their own schedule. In addition to public outreach, the SEM has also been displayed at industrial and manufacturing trade shows to attract the attention of engineering professionals and facilitate new conversations on how industry can partner with and/or leverage resources at the university.

The UW-MRSEC's outreach efforts include giving students an authentic research experience which includes a rigorous approach to quantifying observations, developing some understanding of a complex tool, and interpreting the generated data. One way this is achieved is through the demonstrations of the SEM showing objects such as a tungsten light-bulb filament, insect body parts, metallic foams, human hairs, and cause and effect (before/after surface chemical treatment) of microstructures. Simple, but potentially deep questions, are posed about the differences and limitations of an optical microscope compared to an electron microscope and how the images are formed –making the operation of the electron microscope as interesting as the specimen being studied. The conceptual description of how electrons are used to collect images gives audiences a new perspective on the limitations of light and how other tools must be used to detect objects that are smaller than lightwaves. The application of the SEM is connected back to core materials science concepts and topics that are being explored by researchers in the MRSEC and why a tool such as the SEM is useful and unique in the research process.

On campus, the SEM is used for programs and events that enable participants to interact with the SEM to varying degrees. The UW MRSEC Research Experience for Teachers (RETs) program is an intensive 6-week professional development program that gives K-12 teachers an opportunity to participate in authentic research under the mentorship of faculty, post-docs, students and staff for K-12 teachers. In addition to research the RET participants collaborate with their host labs to develop classroom curriculum based upon their research experiences. During the past 4 years, RET participants were trained to use the tabletop SEM and several incorporated the instrument and/or images taken with it into their curriculum modules. The UW MRSEC RET program is unique because it is part of a cross-cultural site program between the UW MRSEC and the University of Puerto Rico at Mayagüez (UPRM). Teachers from Puerto Rico participate in research at UPRM in parallel with the teachers at UW and they travel to Wisconsin for a capstone week program. During capstone week, teachers from Puerto Rico receive training on how to use the SEM and have the opportunity to collect images for their own curriculum projects (Fig. 1), thus expanding the SEM's use beyond Wisconsin to Puerto Rico. This provides teachers with research experience, new ideas and tools, builds networks among the school and universities, and encourages cultural literacy. In addition to RET, the SEM has also been presented at large community events, such as the Wisconsin Science Festival (~2500 attendees), Engineering Expo (~3000 attendees), and Saturday Science Events (~600 attendees each). In a partnership with the Wisconsin Institutes for Discovery (WID)— an open forum and research facility with a large community space that fosters public interactions between the public and UW faculty, staff, and student, the SEM has been used for a K-12 field trip experience where students (~150) from local schools come to the UW for a 70 minute in-lab field trip. Another outreach component of the MRSEC is with local industry. This interaction facilitates new partnerships between the UW-Madison and regional companies that typically take the form of:

- additional industrial users of the instrumentation facilities, which helps maintain the instrument;
- student capstone projects guided by industrial contacts, which are good for internships and industrial recruitment efforts,
- consulting and sponsored research opportunities for students and faculty.

Many existing relationships have been seeded by these meetings at trade shows and regional conferences in the areas of materials and manufacturing. The UW-MRSEC sponsors booths at these events with personnel and information about resources and access to the university. Industrial interest in the booth increased noticeably when the SEM was present. The EDS capability was particularly interesting as some visitors inquired about the composition of their rings and wedding bands.

In summary, the utility of this tabletop SEM has been a significant and positive addition to the UW-Madison's education and industrial outreach efforts. It has provided thousands of K-12, public and industry audience members the opportunity to collect and analyze images on a research instrument that is not typically available to most people.

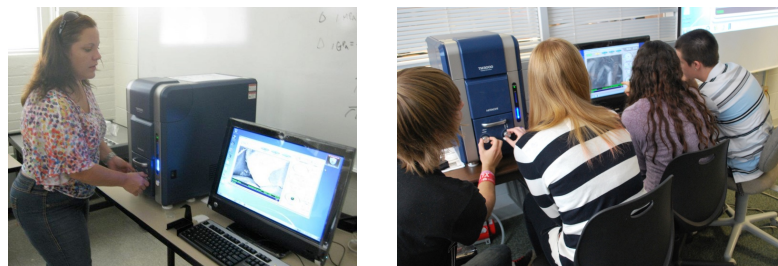


Figure 1: (Left) A teacher visiting from UPRM uses the SEM (Right) The SEM on loan to schools and communities.