A "remote" future for electron microscopy facilities

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Efforts to explore the feasibility and practicality of operating electron microscopy instruments from a distance have existed for years in various forms [1-4]. In general, the goal is to enable the highest possible utilization of a scarce resource, namely powerful, expensive electron microscopes and associated analytical instrumentation. Universities and research organizations often require the use of electron microscopes but lack the infrastructure or the capital to acquire and maintain the modern, high-performance, corrected TEM instruments. At the Center for Electron Microscopy and Analysis (CEMAS) at our focus is to enable tools to expand local user base and build a critical mass of users by fostering high quality collaborations. Facilitating remote operation to teach and train large groups of students, simultaneously [4-6] helps to build this user base and expand exposure to characterization techniques. Whether an off-campus outreach effort, or a classroom demonstration, these educational efforts seek to build excitement for science, and show the wonderment of "seeing the unseen" to students of all ages.

Frequently, software-based tools such as VNC or Remote Desktop Connection are utilized to achieve remote operation of microscopes, thanks to their ubiquitous nature and low cost [7]. While such tools are invaluable for execution of long-duration experiments and to monitor maintenance operations they have limitations; the high bandwidth and low latency video necessary for normal operations, such as alignments, require real-time interaction and cannot be properly facilitated by current software solutions. The continuously changing nature of the software industry and increasing security concerns present obstacles for current procedures and threaten future remote microscopy efforts. CEMAS is currently using several technologies for operation of TEM, SEM, and Dual-Beam FIB instruments. The facility is also evaluating multiple remote-operation scenarios involving private networks and the public internet.

In this contribution we will discuss the implementation of high-performance remote operation of the CEMAS facilities. We will describe our "collaboratory" - a hybrid teaching environment that allows students to interact with every instrument at CEMAS and allows educators to integrate practical training into their teaching materials. This integration of remote operation of electron optical and x-ray instrumentation into existing Material Science and Engineering (MSE) courses has led to valuable insights and revealed curricular challenges that need to be addressed. In particular, there is a need for an evidence-based course development process that will leverage the curricular enhancement afforded by technology mediation via remote instrument operation. CEMAS, in conjunction with North Carolina Agricultural and Technical State University (NCA&T), is developing such a course that will lead to a new paradigm in both local and distance characterization education. Beyond the local environment, we will describe how CEMAS is installing TEM consoles across the state of Ohio using OARnet - the Ohio Academic Resource network. With the implementation of remote consoles at partner sites such as the Air Force Research Laboratory (AFRL), University of Dayton and NCA&T, CEMAS seeks to demonstrate production quality remote operation and establish a model for a "hub and spoke" microscopy resources.

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