SPOTLIGHT ON A CORPORATE SUSTAINING MEMBER (CSA CSM)

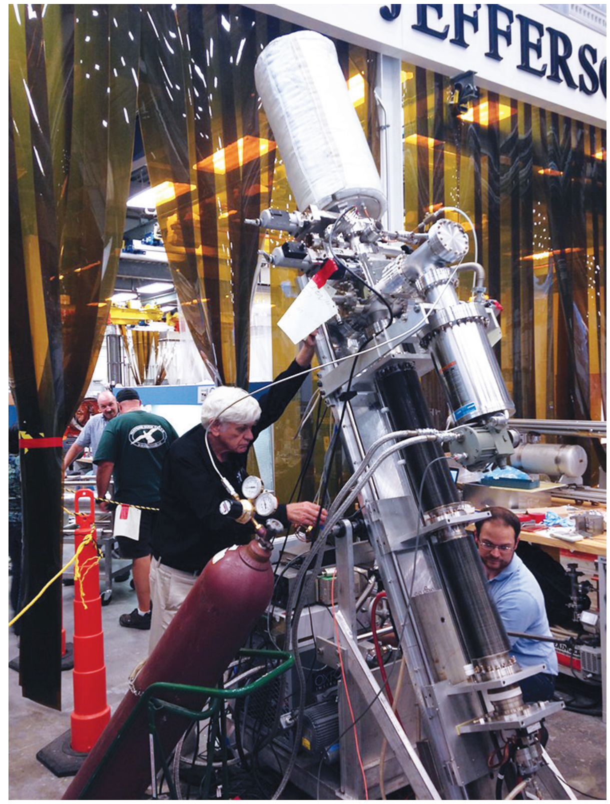
JLab Research Advances Niobium Film Deposition

Researchers at Thomas Jefferson National Accelerator Facility (JLab) have developed and are now testing a new system to coat the interior of copper cavities with a thin superconducting layer of niobium. If successful, the technique could significantly lower the cost of cavity production and therein the expense of superconducting radio frequency (SRF) accelerators.

Cavities today are produced with expensive bulk sheet metal niobium. JLab's system uses high power impulse magnetron sputtering (HiPIMS) to apply a thin layer of niobium to the interior of a copper cavity. The process involves pulsing a magnetron. During the short, intense and high current pulse, the niobium is substantially ionized. "You can make a lot of niobium ions this way," says Larry Phillips, senior SRF physicist at JLab. "We could have chosen a number of different ways to deposit niobium film on the inside of the cavity energetically. The reason we chose the HiPIMS system is because it is the most direct path, requiring little development."

The system is direct, he explains, because it builds on processes that have been used for years. The idea of using niobium films over a substrate, for example, isn't new. The LEP accelerator at CERN used niobium films over copper cavities, and those cavities performed within the design specifications for the machine at that time, according to Phillips. "Until energetic condensation came along there was really not an opportunity to make better films. Otherwise they would have used it back then." Several other labs are also working on this problem using HiPIMS. The system developed at JLab differs in that it is designed to study all issues known as potentially limiting factors in SRF thin film performance.

Matthew Burton, a William & Mary PhD candidate in physics under Professor R. A. Lukaszew as research advisor, and Lukaszew are working with Phillips. The Department of Energy (DOE) in December 2014 presented Burton with a DOE Office of Science Graduate Student Research award. This support allows Burton to work on this project for his thesis, "Development and Characterization of Superconducting Thin Films for SRF Accelerator Cavities."



Larry Phillips (foreground, left) and Matthew Burton (foreground, right) prepare to bake a copper cavity inside the heat shield blanket (upper section) of the HiPIMS device. They will next deposit a thin film of niobium, seal the cavity vacuum and then directly perform a cryogenic test of the cavity's functionality. Image: C. Reece, JLab

"The technology is very promising," says Burton. "I'd say we're close to having a completed cavity. The nice thing about science is even when things don't work exactly as desired, we learn something new. But we expect this to work."

The HiPIMS system allows for both small sample and cavity deposition. Small sample tests have been successful and the team is now trying for proof of principle with a cavity. Cavities undergo rigorous testing in JLab's vertical test area after the niobium film deposition is complete.

"There are a few bugs to iron out but we will have a bugless cavity pretty soon," says Phillips. When a recently produced cavity failed RF testing, the team discovered an air leak had occurred during the deposition. "The commissioning phase is really to get rid of these problems and I think we are at the end of that list now."

Once Phillips and Burton have succeeded in adding niobium film to a copper substrate, they plan to test the same process with aluminum. "Copper is not our material of choice," Phillips says. The team also plans to, in time, experiment with multilayer films, an idea developed by Alexander Gurevich, a theorist also connected to JLab.

One potential multilayer film would have a layer of niobium, an insulating layer and then another layer of a high-Tc material like niobium-3-tin (Nb_3Sn), a design concept also developed by Gurevich. This structure would change the barrier to vortex entry into the Nb_3Sn layer and allow for higher accelerating fields for the cavity. "That process looks pretty promising," Phillips explains. "We're already in a position and have the equipment to do a multilayer deposition in the same system that we've already built." **www.jlab.org**

Larry Phillips (left) and Matthew Burton visually inspect a clean copper cavity which has been prepared for the HiPIMS process to apply a dense thin film of niobium on the inner surface of the cavity. Image: C. Reece, JLab