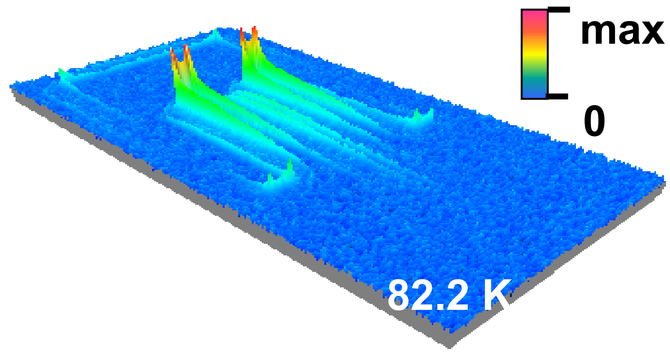
Imaging Sources of Nonlinearity in Superconducting Microwave Devices

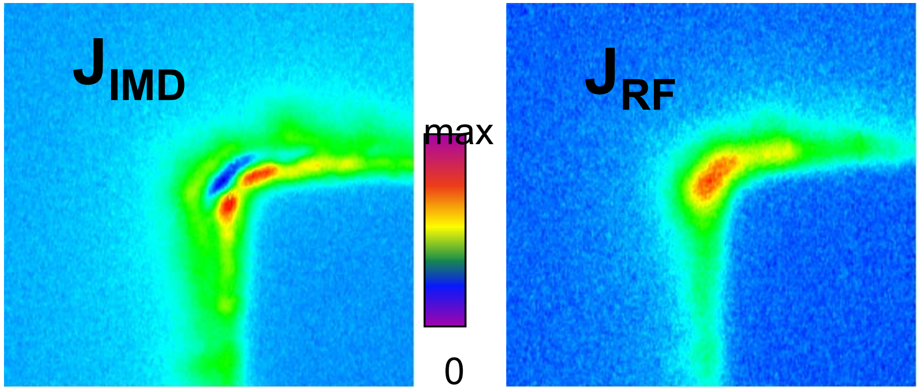
Steven M. Anlage, University of Maryland, DMR-0201261

Superconducting microwave devices have demonstrated outstanding performance improvements in wireless telephone networks. However, these materials suffer from strong nonlinearities, and companies making these devices only have limited control over them. We have developed a unique new microscope (the LSM) to image both microwave current flow, and the microscope origins of nonlinearity (intermodulation) in superconducting microwave devices. This has led to new insights and pointed the way to improved wireless performance of the superconducting devices.

Applied Physics Letters **81**, 4979 (2002).



Laser Scanning Microscope (LSM) image of a superconducting microwave filter in operation at 82.2 K



Close-up (50 µm x 50 µm) view of microwave current density J_{RF} (right) and intermodulation current J_{IMD} (left) near an inside corner of the device shown above.

Superconducting microwave devices have demonstrated outstanding performance improvements in wireless telephone networks. They improve the range of wireless base-stations and increase the throughput compared to using normal metal components. However, these materials suffer from strong nonlinearities, and companies making these devices only have limited control over them. The nonlinearities are manifested through ‘intermodulation’. This occurs when two signal tones are sent into the device, and its nonlinear response produces additional tones that mimic the appearance of other tones/users. Minimizing this intermodulation response is a major concern. However, the microscopic features of the superconducting films and their structure that cause intermodulation have not been identified. We have developed a unique new microscope (the LSM) to image both microwave current flow, and the microscope origins of nonlinearity in superconducting microwave devices. The latter comes through images of what we call the intermodulation current density, J_IMD. This has led to new insights and pointed the way to improved wireless performance of the superconducting devices.

See Applied Physics Letters **81**, 4979 (2002); IEEE Transactions on Applied Superconductivity 13, 340 (2003).

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Education:

One undergraduate (Gregory Ruchti) and one graduate student (Sheng-Chiang Lee) contributed to this work. Gregory won a prize at graduation for his senior thesis, and is a graduate student in physics at Hopkins. Sheng-Chiang Lee received his Ph.D. in 2004 and is presently a postdoc with Steven Hill at the University of Florida. Further experiments are planned.

Industrial Impact:

Our results are of direct relevance to industry. We have had extensive Industrial Liaisons with Steve Remillard (Illinois Superconductor and Agile Devices), Andrew Schwartz (Neocera) and with Superconductor Technology Inc. We have also worked extensively with Dr. Alexander Zhuravel in Ukraine.

Societal Impact:

Our results will improve the performance of wireless networks and help to increase its bandwidth. These results will improve the products made by American companies and keep the US at the forefront of technology