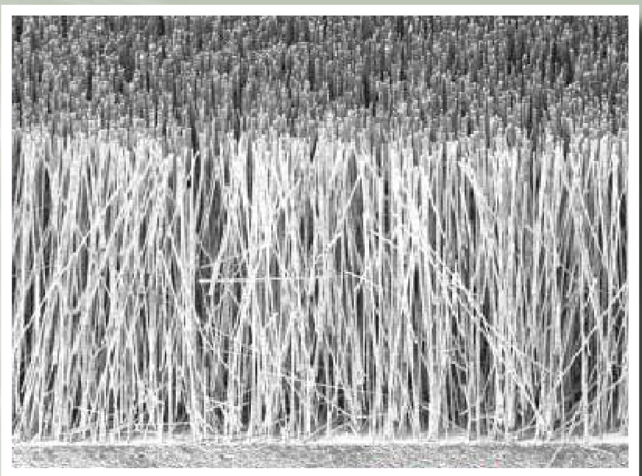
Nano-Coating Enables New Class of High-Power Microwave Devices

Accomplishment: High power microwave devices with enabling improvements in power output, size, weight and lifetime were developed, produced and tested. These benefits were achieved with a new cathode that relies on a cesium iodide coating roughly 100 nanometers thick.

Impact: This advancement is currently used in all Air Force high-power microwave sources. It has enabled counter electronic warfare and plays a vital role in Airborne Electronic Attack by reducing system size, weight and power consumption. The detonation of improvised explosive devices (IEDs) at a distance was demonstrated in field tests and is now possible. This cathode material was transitioned to the commercial sector to generate non-weaponizable X-rays for scientific research, non-destructive evaluation and medical imaging.

Motivation and Approach: High-power microwave devices emit short bursts of very high energy microwave radiation that can be focused into a beam. These are weaponizable devices that can be used in counter-electronic warfare to defeat adversary computers, communication networks and missile navigation and control at a distance. High-power microwaves can also be used to detonate improvised explosive devices (IEDs) at a distance. The effectiveness of earlier high-power microwave devices was severely limited by field emitter cathodes that suffered from short lifetimes, or thermionic emitter cathodes that had low power conversion efficiency and high weight. Significant improvements in cathode technology were needed to make high-power microwave devices practical.

This accomplishment developed and tested high-power microwave devices with a new cathode material consisting of a ‘carpet’ of carbon fibers with a cesium iodide coating that is roughly 100 nanometers thick. The cesium iodide coating reduces the energy needed to extract electrons, which are then passed through a magnetic field to produce microwaves, from the carbon fiber. This lower work function gives a five-fold increase in power conversion efficiency, from less than 10% to over 40%, significantly increasing the microwave beam power and reducing the size and weight of the device. The cesium iodide coating also reduces cathode damage, dramatically extending device lifetime from less than a few thousand pulses for earlier cathodes to over one million pulses. Cesium iodide coatings much less than 100 nanometers did not significantly reduce the work function, and thicker layers inhibited electron emission dramatically.



Team: The research team included Dr. Don Shiffler, Dr. Michael Haworth, Dr. Ryan Umstattd (now at Oak Ridge National Laboratory), Dr. John Luginsland (now at NUMEREX, Inc.) and Dr. Susan Heidger at the Directed Energy Directorate. Additional significant contributions were made by interactions with Energy Sciences Laboratory Inc., SAIC Inc., Sandia National Laboratory and Ktech Corp.