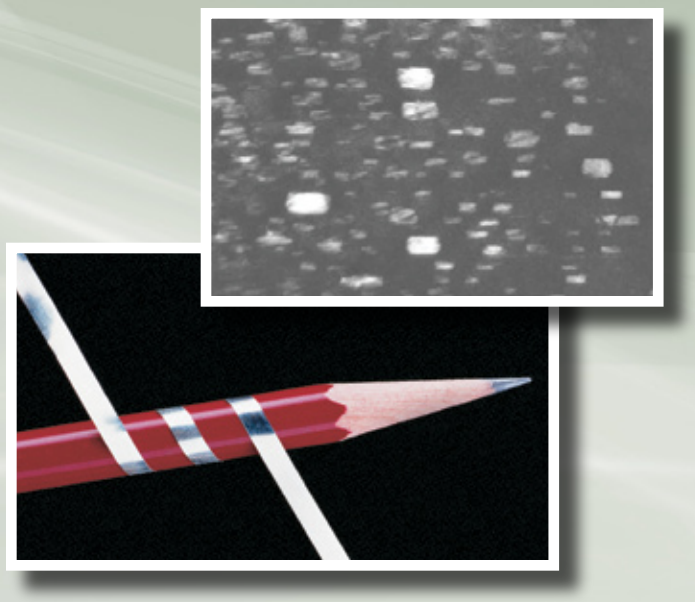
Nanoparticles Enable Superconducting Wire for Compact Power Systems

Accomplishment: Nanoparticle additions have increased by more than 10 times the electrical current carrying capability of high temperature superconducting (HTS) wire. This breakthrough increases efficiency and operating temperature and enables a dramatic 2-4 times reduction in power systems size over conventional generators.

Impact: HTS-coated conductor enables compact sources of high-power electricity that are essential to national defense. Military uses include power generators, gyrotron magnets, power converters, transformers, motors, primary power cabling, and magneto-hydrodynamic magnets. HTS conductors reduce the size of the power generator and the microwave-producing gyrotron magnet for airborne and ground-based active denial systems that will provide non-lethal anti-personnel capabilities via high power microwaves. This technology reduces power generator cooling loads and refrigeration system size by over 80 times. First demonstrated at AFRL, this advancement has become the industry standard for commercial HTS materials and has launched a new field of study and development.

Motivation and Approach: Since their discovery in 1986, HTS materials have been pursued for compact power systems. Previous state-of-the-art HTS conductors enabled generators that could produce several megawatts of electrical power while using only about 40% of the mass and volume of conventional generators. However, the high magnetic field within the conductor limited electrical supercurrents near the 77K operating temperature, reducing the power produced and increasing cooling requirements. These debits added significantly to power system size and cost, reducing the benefit of earlier HTS technology.

AFRL scientists demonstrated that HTS current-carrying capability is dramatically improved by adding a high density of insulating nanoparticles. These nanoparticles pin the moving magnetic flux, allowing larger supercurrents and higher electrical current-carrying capacity. Pulsed laser deposition was used to create a multilayered superconductor with a carefully controlled nanoparticle dispersion, essential for achieving this effect. This major advancement allows development of power sources only one fourth the size and weight of conventional units. This technology has been commercialized in the international superconducing industry, and has enabled continued progress toward the development of compact power sources critical for Defense applications such as that used by the Airborne Active Denial Technology.



Team: Dr. Paul Barnes and Dr. Timothy Haugan of the Propulsion Directorate were responsible for the technical innovation leading to this accomplishment. Scale-up and commercialization were achieved at SuperPower, Inc. and American Superconductor Corp. through a Defense Production Act Title III program and dual use funding from the Propulsion Directorate.