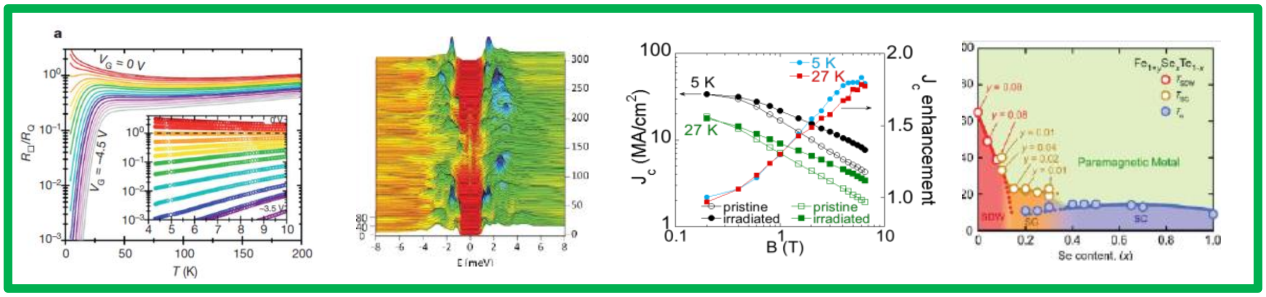
Center for Emergent Superconductivity (CES)
EFRC Director: Peter D. Johnson
Lead Institution: Brookhaven National Laboratory
Start Date: August 2009

Mission Statement: *To discover new high-temperature superconductors and improve the performance of known superconductors by understanding the fundamental physics of superconductivity.*

As U.S. electrical energy consumption continues to grow, the nation's electrical power transmission grid faces fundamental structural challenges of capacity, reliability and efficiency if it is to meet the needs of the 21st century. Electricity demand will grow by 50% in the US and by 100% globally by 2030, with nearly all of that growth in cities and suburbs where the overhead power lines and underground cables are already saturated. Power delivery and control solutions based on superconductors could solve these crises by using their demonstrated higher current carrying capacities over conventional cables, self-healing fault current limiting capabilities, and substantial increases in efficiency. However, there remain many fundamental materials and physics challenges which must be addressed in order for superconductivity to have a broad impact on the electrical grid.



From left to right: Superconductor-insulator transition in cuprate thin films driven by field-effect technology; STM measured superconducting gaps in the vortex core region in an FeTeSe superconductor; Magnetic field dependence of the critical current density J_c demonstrating the critical current enhancement due to ion-irradiation of commercial YBCO coated conductors; Phase diagram of the iron-based superconductor FeTeSe.Phase diagram for the iron based superconductor $FeTe_{1-x}Se_x$ as a function of the doping level x.

The objective of the *Center for Emergent Superconductivity* (CES) is to explore fundamental research issues with the objective to overcome key barriers leading to the viable application of high temperature/high current superconductivity. This will be achieved by enabling the design of superconducting materials with optimal physical and critical properties for deployment of a 21st century superconducting power grid. Thus, the most profound challenge of CES is to understand the fundamental mechanisms of high-temperature and high-current superconductivity sufficiently so as to direct discovery of new or improved families of materials with higher critical temperatures and currents. Considerable progress has already been made in this area with the demonstration that ion irradiation may be used to enhance the critical current carrying capabilities of commercial superconducting cable.

The central mission for the CES is the development of a broadly defined *Materials Genome Initiative* that encompasses three highly coordinated fundamental research directions specifically designed to work symbiotically towards the greater goal of the fundamental understanding high-temperature superconductivity. These are: a) the development of techniques to create new classes of superconducting materials by design; b) a fundamental understanding of the mechanism of high-temperature superconductivity in existing materials, including the cuprates and Fe-based superconductors; and c) a fundamental understanding of the current carrying limiting properties of existing high-temperature superconductors that will lead to applications performance enhancement by design. We expect the unification of these priority research directions will prove transformative in our fundamental understanding and provide the basis for predictive design of new families of high-temperature superconductors.

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