From Nano Defects to Mega Power: Heavily-Zirconium-Doped Trapped Field (Gd,Y)BaCuO Superconductor Tapes for High Power Wind Turbine Generators

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The economics of wind energy can become a lot more favorable with high power wind turbines which could be feasible with higher-field magnets. (Gd,Y)BaCuO superconductor tapes with embedded $BaZrO_3$ nanoscale defects can trap magnetic fields and work as magnets. The purpose of this project was to determine how the magnetic field trapped by a superconductor tape stack and in turn, the power produced by a wind generator are influenced by nanoscale defects. Profiles of trapped magnetic fields in the thin film tape stacks were obtained over a range of 30 K to 77 K by simulation with COMSOL. The trapped magnetic field values at different temperatures were verified experimentally using a 5 Tesla magnet to magnetize the tape stacks and a Hall probe array to measure the trapped-field values. The average trapped fields over a temperature range of 30 to 77 K from the simulation matches well with experimental results. Higher trapped magnetic fields were obtained in the 25% Zr-added tape stack at 30, 40 and 50 K whereas the 7.5% Zr-added tape stack exhibited the highest trapped field at 77 K. Average and peak trapped field values above 2.5 T and 4.5 T respectively were obtained in 25% Zr-added tape stack at 30 K, which are well above the capability of permanent magnets. Using a ANSYS Maxwell model, it was found that the power produced by wind generator increases as the square of the magnetic field at the superconducting rotor poles. Additionally, it was seen that 10 MW power is produced at a magnetic field of 2 Tesla and 13.6 MW is generated at 2.57 Tesla. These power levels are well above that possible with permanent magnets (2 – 6 MW) and hence high-power wind turbines enabled by superconductor tapes with nanoscale defects can make wind energy more economical.

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