Wolfson Department of Chemical Engineering Seminar

Monday, April 7th, 2025 at 13:30

Room 6

Spark Plasma Sintering of High-Voltage Layered Ceramic Insulators and Textured Thermoelectric Materials

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Ph.D. Seminar

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Spark Plasma Sintering (SPS) is an advanced sintering technique that combines heating by pulsed direct current (DC) under uniaxial pressure, enabling the rapid densification of materials. SPS is known for reducing sintering temperatures and processing times, which minimizes grain growth and preserves the material's nanostructure. Therefore, SPS is highly effective in sintering difficult-to-process materials facilitating production of materials with enhanced performance.

This seminar presents the application of SPS in two distinct fields: vacuum high-voltage layered ceramic insulators and textured thermoelectric materials. In the first field, SPS is utilized to fabricate dielectric high-gradient insulators (DHGIs), which are alumina-based layered structures designed to mitigate surface breakdown, a common failure mode in vacuum high-voltage systems. High-gradient insulators (HGIs), which are composed of alternating ceramic and metallic layers, have been shown to mitigate surface breakdown by controlling the electric field distribution on the insulator surface. The DHGI structures aim to achieve the same surface breakdown prevention as HGIs; however, as fully ceramic structures, they are designed to overcome the challenges associated with metal-ceramic HGI configurations. A trilayers DHGI exhibited a 33.5% higher breakdown field than monolayer plain alumina, demonstrating its potential for improved insulation performance.

In the second field, SPS is used for the preparation of thermoelectric materials with enhanced properties to improve energy conversion efficiency in thermoelectric generators. A technique called Spark Plasma Texturing (SPT), a modification of SPS, is applied to fabricate highly textured calcium cobaltite (CCO) p-type semiconductors. This technique promotes anisotropic grain orientation, which enhances in-plane thermoelectric properties such as Seebeck coefficient and electrical conductivity. The unique two-step (SPS-SPT) procedure demonstrated in this work resulted in a high degree of texturization, achieving a remarkable figure-of-merit (ZT) of 0.49 at 1073 K in air for polycrystalline CCO.