Materials Challenges in Solid Oxide Fuel Cells

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The high oxide ion conductivity over wide ranges of temperature and oxygen pressures in stabilized zirconia has led to its use as a solid oxide electrolyte in a variety of electrochemical applications. These include high temperature solid oxide fuel cells (SOFCs) which offer a clean, low-pollution technology to electrochemically generate electricity at high efficiencies. These fuel cells provide many advantages over traditional energy conversion systems including high efficiency, reliability, modularity, fuel adaptability, and very low levels of SO_x and NO_x emissions. The most progress to date has been achieved with the tubular design cells; however, their electrical resistance is high, and specific power output (W/cm^2) and volumetric power density (W/cm^3) low. Planar solid oxide fuel cells, particularly anode-supported, in contrast, are capable of achieving very high power densities and can be mass produced using low-cost conventional ceramic processing and microelectronic fabrication techniques. This lecture will review the materials, fabrication processes and performance of these solid oxide fuel cells and discuss their applications in stationary power generation, transportation, and military market sectors.