High Temperature Electrochemical Test Station

Kantesh Balani (MSE), Raj Pala (ChE) & Malay Das (ME)

Purchased with CARE Grant, IIT Kanpur

High temperature electrochemical test station, Fig. 1, is designed for testing the V-I characteristic of the solid oxide fuel cell (SOFC) using the Probostat fixture with a maximum temperatures of 800°C. The test stations can be used for characterization of components, the evaluation of SOFC single cells or a stack of SOFCs for identifying the weak link in the stack. This system is ideal for researchers and developers to begin or expand their testing of SOFC button cells.

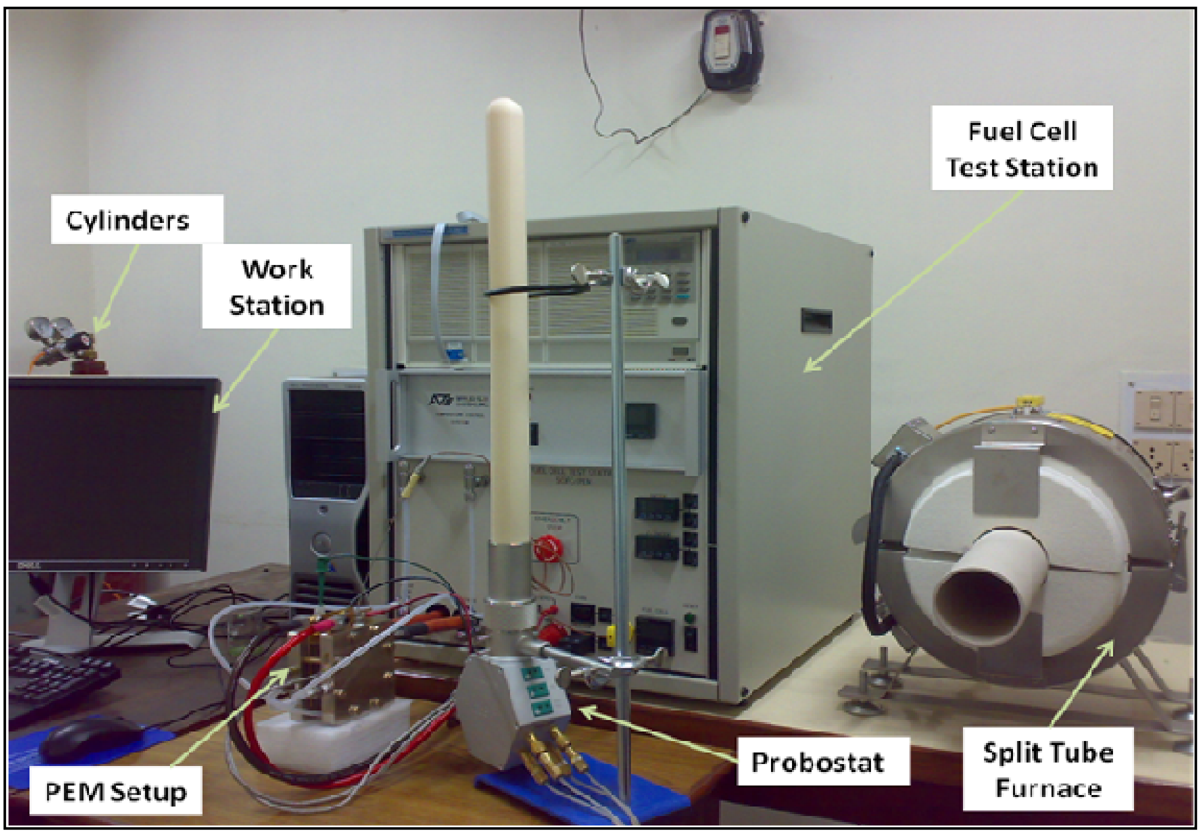

Fig. 1: High Temperature Electrochemical Test Station

Unique features: The test station provides control of flow (MKS Type 1179A and 2179A Mass-Flo Controller and Type 179A mass-Flo Meter), heating rate, humidity, back-pressure (Maximum 70 psig), temperature (Type T thermocouple) and pressure for the anode and cathode gases. The station incorporates a DC electronic load. The Station also includes two humidity bottles.

This station tests single cells and any stack of up to 10 Volts and 100 amps at 150watts maximum power. An electronic load that is programmable through a GPIB/PC interface controls the voltage and current. Its safety features include an anode nitrogen purge, an automatic system shutdown of anode and cathode gas streams, humidity bottles and cell heaters.

The ProboStat is a cell for measurement of electrical properties, transport parameters etc. It is also used to find the kinetics of materials, solid/gas interfaces and electrodes under controlled atmospheres at high temperatures. The furnace is 3210 Series Split Tube Furnace with dimensions 3-3/4 in. ID x 12 in. OD x 9 in. long. The heating length is 6 in. The material used in manufacturing is Kanthal A1 and the maximum achievable temperature is 1100^{O}C. Power Input required is 230V AC supply.

Application: The software reads data and plots a curve of current density vs. voltage, conductivity vs. T, pO_2, pH_2O. Additional information such as flow rates and temperature can also be input to an Excel spreadsheet file. Resistance and an IR free polarization curve can also be plotted with the AC Impedance option.

Research on Developing Electrolyte with enhanced Ionic Conductivity for Solid Oxide Fuel Cell (SOFC):

A solid oxide fuel cell (SOFC) is an all-solid energy conversion device with high efficiency (40-60%) and low emission. It is composed of two electrodes and a solid electrolyte, Fig. 2. The properties of the electrolyte play an important role in the performance of SOFCs. At present, yttrium stabilized zirconia (YSZ) is the most commonly used electrolyte in SOFCs because it possesses an adequate level of oxygen-ion conductivity and exhibits desirable stability in both oxidizing and reducing atmospheres.

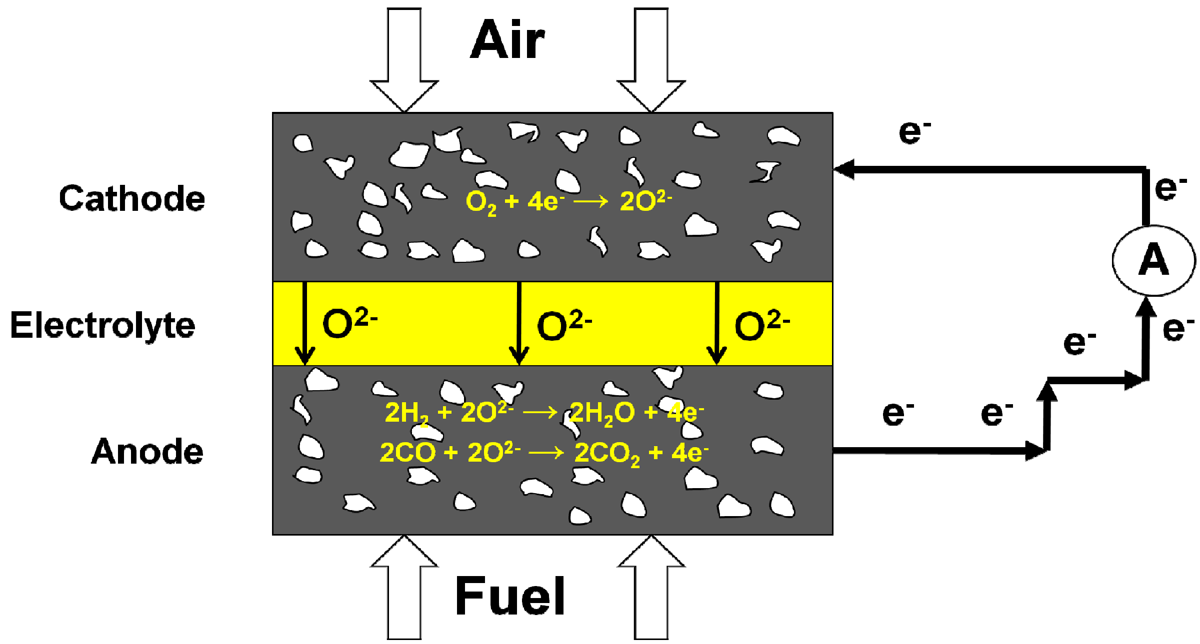

Fig. 2: Schematic of Solid Oxide Fuel Cell (SOFC) showing the oxygen ion diffusion through solid electrolyte from cathode to the anode.

Since current is obtained via diffusion of oxygen ion through a solid electrolyte, it becomes imperative to use high temperatures for achieving enhanced ionic conductivity. But, te high operating temperatures (~800-1000°C) of SOFCs can lead to complex materials problems which include electrode sintering, inerfacial diffusion between electrolyte and electrode materials, and mechanical stress due to different coefficients thermal expansion (CTE) of the cell components. Such problems have limited the commercial development of SOFCs. Lower operating temperatures allow a wider choice of materials to be used as interconnects, including metal alloys. Approaches to minimize resistive losses across the electrolyte have included replacing YSZ by alternative electrolyte materials with higher ionic conductivity, and/or reducing the thickness of the solid oxide electrolyte

In our study we are planning to dope CeO_2 in YSZ and analyze its effect on the mechanical properties and ionic conductivity of the YSZ electrolyte. For this purpose, CeO_2 doped 8 mol% YSZ has been prepared via Spark Plasma Sintering (SPS). Different wt. % of CeO_2 (between 2-10 %) has been added with spray dried and nano sized 8 mol% YSZ to understand the effect of distribution of CeO_2-rich areas on the ionic conductivity (see Fig. 3) and mechanical properties of solid electrolyte.

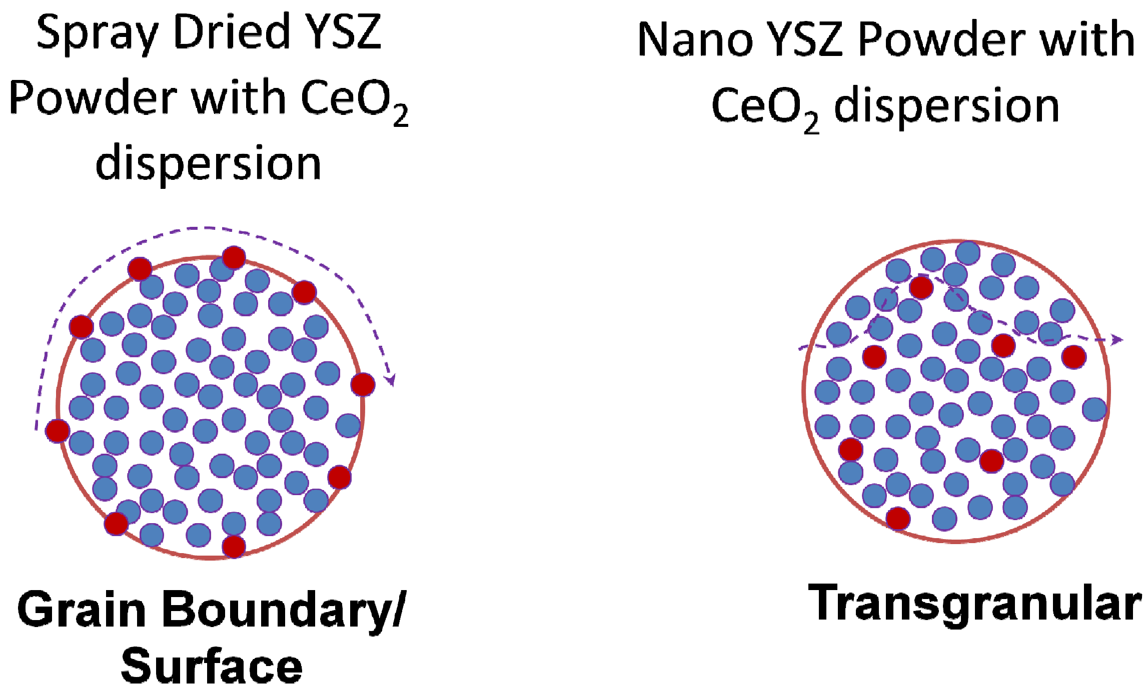

Fig. 3: Role of CeO_2 dispersion on the ionic conductivity of YSZ.

Process optimization has been done to get good density and mechanical properties in the final pellet. X-ray diffractrometry, scanning electron microscopy and energy dispersive spectrometry studies have been carried out to characterize the phase and microstructural evolution of synthesized material and observe the doping of CeO_2 in YSZ matrix. To understand the effect of CeO_2 on the grain growth of YSZ grains, conventional sintering has also been done for different sintering times at constant temperature. A complete SOFC has been fabricated using plasma spraying has been utilized for layered deposition, viz. LSM (Lanthanum Strontium Manganite) as cathode, YSZ-CeO_2/YSZ as electrolyte and YSZ-NiO as anode. Correspondingly nanomechanical testing using nanoindentation revealed enhancement of modulus and hardness (each by 10%) with 10 wt.% CeO_2 doping in YSZ electrolyte.