

**David Halat: Chemistry & Biochemistry**

**Mentor: Rob Walker -- Chemistry & Biochemistry**

***Studies of Solid Oxide Fuel Cells (SOFCs) and SOFC Materials with High-Temperature Raman Spectroscopy***

Materials used in electrocatalytic applications are often subject to extreme nonequilibrium conditions. These conditions include high temperatures (above 1000 K), strong oxidizing or reducing environments, and non-uniform electrochemical potentials. In solid oxide fuel cells (SOFCs), materials encounter all three of these conditions simultaneously. In this work, vibrational Raman spectroscopy and voltammetry were used together to monitor and model the chemical and physical changes in operating SOFCs. The temperature dependence of the Raman spectra of various SOFC materials, such as yttrium-stabilized zirconia (YSZ) and nickel oxide (NiO), was quantified and used to assess sample temperatures in later experiments. By means of temporally resolved Raman measurements, the reduction and oxidation kinetics of ceria and gadolinium-doped ceria (GDC) were determined. These studies provide a basis for understanding the chemical behavior of SOFC materials, which is difficult to measure at elevated temperatures. The deposition of graphite on SOFCs operating with methane was also examined. Electrochemical oxidation of graphite, as monitored with simultaneous chronopotentiometry and Raman spectroscopy, quantified the amount of carbon formed on the cell. This work allows us to correlate performance changes in operating SOFCs with measurable chemical phenomena occurring at the anode. Ongoing research examines reaction kinetics at the triple phase boundary (TPB) of anode-supported SOFCs.