The engineering of oxygen transport through a liquid metal in a liquid metal anode solid oxide fuel cell (LMA-SOFC)

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The liquid metal anode solid oxide fuel cell (LMA-SOFC) is a unique fuel cell system that allows direct utilization of solid and liquid fuels (i.e., coal, biomass, biodiesel), removing the need for a gasifier. The major drawback to the LMA-SOFC is a greatly reduced power density compared to traditional SOFCs. The transport of oxygen through the liquid metal layer and its subsequent reaction with the fuel generate the largest losses in the cell. For pure liquid tin, the potential drop from oxygen transport alone through the tin can be greater than that across the electrolyte. To boost the power density of an LMA-SOFC system, the thickness of the liquid metal layer must be made extremely thin or the oxygen transport rate through the liquid metal must be significantly increased through alloying.

At NETL, thermodynamic modeling and electrochemical measurements are being combined to characterize new tin-based alloys to gauge the possibility of engineering high performance liquid metal anodes. Oxygen transport is dictated by the amount of oxygen that can be carried in the liquid metal before precipitating out as a solid oxide (the oxygen solubility limit) and by the mobility of the oxygen through the metal (the oxygen diffusion coefficient). FactSage, a commercial thermodynamics software, is being used to find binary and ternary tin-based alloys that are single phase liquid alloys between 800 and 1000ºC and that have a higher oxygen solubility limit than pure tin. The chosen candidate alloys are electrochemically tested to determine the oxygen diffusion coefficient and probed with an oxygen sensor to determine the oxygen solubility limit. These parameters are then introduced into a 1-D kinetic model of a LMA-SOFC to determine the overall impact on cell performance for a given cell geometry.