

## A Rotating Electrolyte Disc (RED) for Operation in Liquid Metal Electrodes

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Much interest is currently being shown in the liquid metal anode solid oxide fuel cell (LMA SOFC) which allows operation on a variety of carbonaceous fuels – gaseous or solid, while remaining tolerant towards fuel contaminants (1). The liquid metal electrode resides in a layer between the fuel and solid electrolyte. During current flow oxygen ions migrate through the solid electrolyte, typically yttria-stabilised zirconia (YSZ), to the liquid metal anode. At the interface between the electrolyte and the liquid metal the  $O^{2-}$  ions react electrochemically with the metal, generating metal oxide which in turn reacts with the fuel, producing water (hydrogen as fuel) and/or carbon dioxide (carbon or hydrocarbon as fuel).

With respect to reported earlier uncertainties in performance limitation of LMA SOFC (2) greater understanding of the electrochemical reactions, redox, and transport processes within liquid metal electrodes is needed. There are a number of research challenges, including: transport of oxygen (and other gases) or oxidized species in the liquid metal; reaction kinetics between metal oxide and fuel within the liquid anode; kinetics of oxygen transfer at the liquid metal anode - electrolyte interface; understanding of the action of contaminants and poisons.

This paper discusses the development of a technique to enable the determination of the parameters controlling mass transport of dissolved oxygen (and other gases) and oxidised species including metal oxide in the liquid metal; the technique also provides the possibility of the investigation of heterogeneous and homogeneous reaction kinetics as well as the influence of electrode contaminants.

Conventional rotating disc electrode (RDE) theory is applicable to the high temperature technique discussed here. In our design a solid electrolyte disc rotates in a liquid metal electrode (e.g. tin), as opposed to a solid electrode disc rotating in a liquid electrolyte, making this concept novel and unique. The theory of the RDE is well known for aqueous solutions (3), though it has not previously been applied to the study of solid oxide fuel cells with liquid metal anodes. Operation with liquid tin instead of aqueous electrolyte makes the proposed method interesting and challenging (handling of molten metal and high operating temperature). A schematic of the rotating electrolyte disc (RED) arrangement is shown in Figure 1.

The metal is contained within a closed-end zirconia tube and held at elevated temperatures by an electric furnace. The oxygen content of the liquid metal is controlled by electrochemically ‘pumping’ oxygen into or out of the liquid metal via the zirconia tube with associated external air electrode.



The working electrode in this design is the liquid metal and the electrochemical reaction takes place at the base of the rotating electrolyte. A platinum counter electrode is positioned on the opposite face of the rotating electrolyte disc inside the tube to which the disc is attached. An electrical connection to the counter electrode is made via a bush and a carbon brush. Connection to the working electrode is made via a dipping electronic conductor.

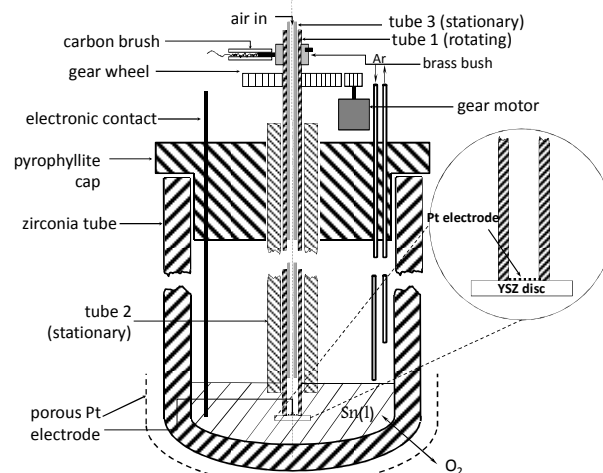


Figure 1 Schematic of RED setup for LME SOFC

In order to demonstrate the validity of the concept and design for high temperature studies, the setup was first tested using an aqueous system at ambient temperature (equimolar solution of ferrous and ferric chloride with KCl as supporting electrolyte and a platinum disc electrode on the base of the zirconia disc), Fig. 2. The obtained data show that the developed design conforms to standard RDE behavior (increasing rotation speed  $\omega$  increased the observed limiting current density)

This paper also presents preliminary results in molten tin electrodes.

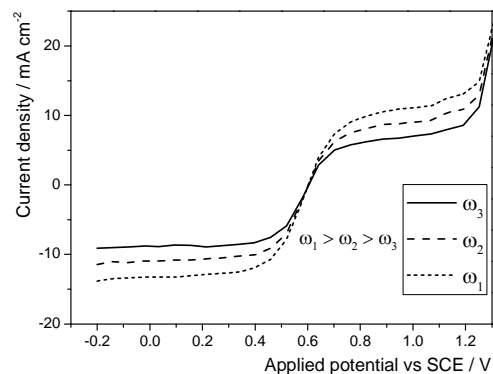


Figure 2 Linear sweep voltammograms with increasing rotation rate for the ferrous-ferric redox couple using  $0.014\text{ M Fe}^{2+} / 0.014\text{ M Fe}^{3+}$  in  $3\text{ M KCl}$

### REFERENCES:

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