Electrochemical energy conversion with oxide thin films: tuning the internal stress for improved performance

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Oxide thin films are being integrated in the design of various electrochemical energy conversion devices. Two examples of such devices are thin film solid oxide fuel cells (SOFC) and solar water splitting cells. For instance, in thin film SOFCs, ~100 nm-thick yttria-doped zirconia films are used as the oxygen ion conducting electrolyte [1]. In solar water splitting cells with silicon-based photoanodes, oxide thin films are used to prevent silicon oxidation at anodic potentials [2]. Decreasing film thicknesses in these two applications can lead to improved performance due to decreased resistance to charge carrier transport. However, as the film thickness decreases, its mechanical behavior could limit the performance of the device. This can be due to mechanical reliability issues, but also to the coupling between the mechanical properties and charge transport.

The internal stress can be controlled by varying the synthesis conditions of oxide thin films [3]. Varying the deposition pressure during magnetron sputtering of yttria-doped zirconia allowed us to vary the internal stress from -1400 to +100 MPa, as illustrated on Fig. 1(a). Subsequent release of the thin film electrolytes into freestanding electrolyte membranes and deposition of anodes and cathodes produced thin film solid oxide fuel cells. As can be seen in Fig. 1(b), the internal stress in the electrolyte thin film is an important factor in determining the open circuit potential difference at which the fuel cell operates. The open circuit potential difference is closer to the thermodynamic Nernst potential for small values of compressive internal stress. Deviations from the Nernst potential could be due to defects in the electrolyte thin film. In my presentation, recent results on the influence of the internal stress on the performance of oxide thin films used in silicon-based photoanodes will be presented as well.

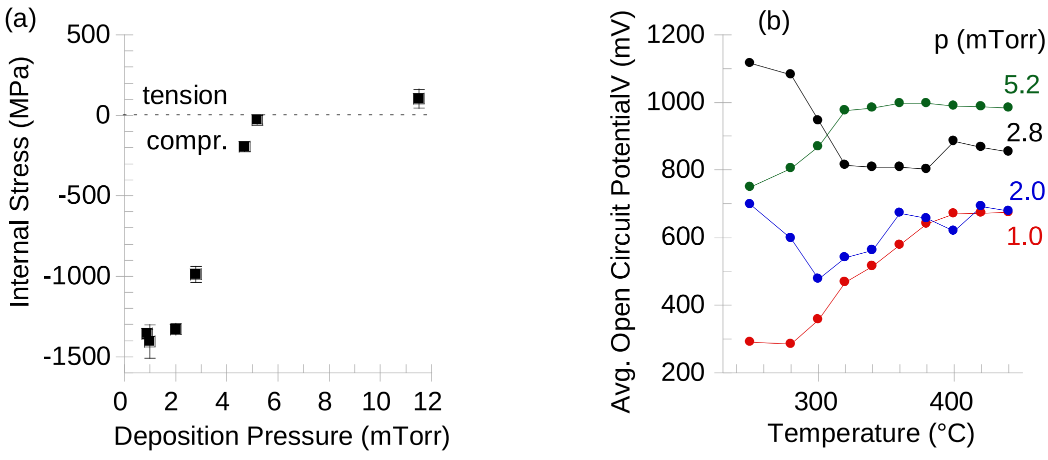

Fig1. (a) Variation of the internal stress in yttria-doped zirconia thin films deposited by magnetron sputtering at different pressures. (b) Average open circuit potential difference of thin film solid oxide fuel cells fabricated with yttria-doped zirconia electrolytes deposited at different pressures.

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