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Thin oxide films applied as models systems for energy applications

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Abstract:

Pulsed laser deposition (PLD) is a highly flexible technique which is well suited for the deposition of thin oxide films. These films can be either applied as model systems for energy applications or can be utilized in microdevices.

Thin films of dense, particulate-free, ion conducting materials (solid electrolyte) e.g. yttria-stabilized ZrO_2, are a requirement to build micro solid oxide fuel cells (µ-SOFC) operating at low temperatures (≤ 500 °C). These thin films can be deposited by various techniques, e.g. PLD, sputtering, or spray pyrolysis, etc., but the necessity to form dense films makes PLD an attractive method. The design of a µ-SOFC, where the thin solid electrolyte layer must be deposited on a membrane is rather challenging, and a "soft" processing approach is needed. PLD can be applied to deposit x-ray amorphous YSZ films at room temperature, which crystallize at surprisingly low temperatures (~250 °C). As a resul t the strain in these YSZ film is considerably reduced which is important for the assembly of fragile µ-SOFCs. The low crystallization temperature for the x-ray amorphous PLD films is especially remarkable as amorphous films prepared by sputtering require crystallization temperatures of > 800 °C. The µ-SOFC containing fil ms deposited by PLD are functional and produce electricity at temperatures ≤ 500 °C.

Li-metal oxides are used as electrode materials in re-chargeable Li-ion batteries and are one example where thin films deposited by PLD serve as model systems for fundamental electrochemical studies. These oxides show exemplary the limitations of PLD thereby emphasizing the need and importance of a careful process control and material analysis. A congruent transfer of the Li manganite oxide seems to be impossible, i.e. all films are Li deficient and targets with an excess of Li must be applied. The thin films can be used to study the formation of the so-called solid electrolyte interphase, which is a layer that may inhibit the Li-diffusion upon charge/discharge cycles. The influence of the cycling parameters, such as electrolyte, can be studied in detail with the thin model films.