High proton conduction in grain-boundary-free yttrium-doped barium zirconate films grown by pulsed laser deposition

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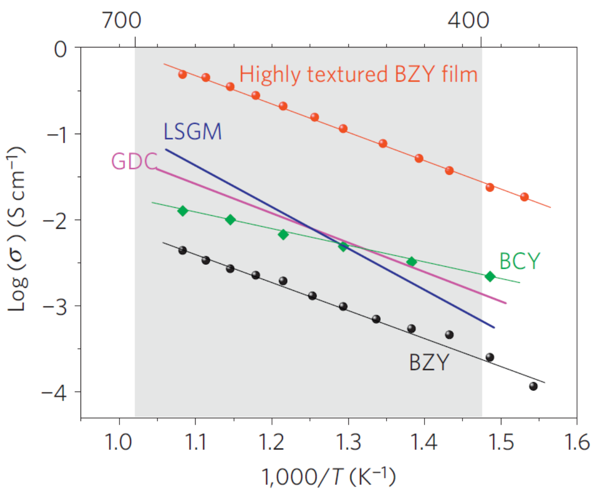
Nature Materials 9, 846–852 (2010)

High quality, grain-boundary free, thin films of yttrium-doped barium zirconate ($BaZr_{0.8}Y_{0.2}O_{3-\delta}$, BZY) were produced using the pulsed laser deposition apparatus available at the CNR-SPIN "Tor Vergata" laboratories. These films exhibited the largest proton conductivity values ever reported for BZY samples, namely 0.11 S/cm at 500°C and 0.01 S/cm temperatures as low as 350°C.



Electrical conductivity comparisons. (a) Comparison between the electrical conductivity and activation energy values of the BZY films grown on MgO and sapphire, and of BZY sintered pellets, measured in the intermediate temperature range, with the bulk conductivity values of BZY pellets measured at low temperature. The differences in the measured activation energy values with the literature data indicate some structural and/or chemical differences between the bulk of the samples prepared using PLD and ceramic processing. (b) Comparison between the electrical conductivity values of the BZY film grown on MgO, and of BZY and BCY sintered pellets, measured in the intermediate temperature range. Conductivity values of the most performing oxygen ion conducting materials, $La_{0.8}Sr_{0.2}Ga_{0.8}Mg_{0.2}O_3$ (LSGM) and $Ce_{0.8}Gd_{0.2}O_{1.9-\delta}$ (GDC), are also reported.

These conductivity values are substantially larger than those attained by the $La_{0.8}Sr0.2Ga_{0.2}O_3$ (LSGM) and $Ce_{0.8}Gd^{0.2}O_{1.9-\delta}$ (GDC) that were presently considered to be the oxygen ion conductors with the highest conductivity in the same temperature range. The high conductivity values of the BZY films, in the intermediate temperature range, mean that the this proton conductor maybe thought of as a possible substitute for the oxygen-ion conductor electrolytes conventionally used in solid oxide fuel cells (SOFCs).
Common to other proton conductors the BZY also offers the important advantage that the water exhaust is produced at the cathode side, avoiding fuel dilution with water and improving efficiency. In order to be used in a wide range of applications it is mandatory for the SOFCs to exhibit a decrease in operating temperature to below 700°C and more specifically to below 450°C for their use in portable electronic devices (laptop, mobile phone, etc.) to substitute Li-ions batteries. The absence of charge-discharge cycles and a larger energy density are the main benefits offered by the SOFCs with respect to Li-ions batteries. Our results demonstrated that the highly ordered BZY films without grain boundaries, obtained by pulsed laser deposition, are one of the most performing electrolytes ever developed for SOFC use and open new perspectives in the development of miniaturized SOFCs for a wide range of electronic device applications