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Oxygen-ion Transfer between YSZ/YSZ and YSZ/LSCF under Mechanical Contact Stress

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Yttria stabilised zirconia (YSZ) is known as an oxygen-ion conducting material and one of the common electrolyte materials for solid oxide fuel cell (SOFC) due to its good ionic conductivity as well as chemical and mechanical stabilities.

For polycrystalline YSZ, the oxygen-ion transport property is attributed to the oxygen ion conductivities of bulk (grain) and grain boundary, and it has been generally known that oxygen-ion conductivity in bulk is superior to that in grain boundary. Nanocrystalline YSZ has a large specific area of grain boundary, thus the conductivity of grain boundary, including transports between the grains and also in/along the grain boundary, is critical, although the observed behaviours seem to be controversial, and possible microscopic stress has not been considered. On the other hand, the oxygen-ion conductivity of YSZ nano-films strained in a multilayer structure has been intensively studied. Significant enhancement of the conductivity due to stress/strain has been observed, although the stress effect on grain boundary conductivity has been less discussed compared to that on other contributions such as conductivities of bulk and interface between substrate layers.

The oxygen-ion transport characteristics of the grain boundary in YSZ are normally extracted from the characteristics of polycrystalline samples, whereas it has been also evaluated using bicrystal or two single crystals in previous studies. A direct oxygen ion transfer between YSZ/YSZ involving no neutral oxygen atom was confirmed, although a large resistance due to the interface between YSZ/YSZ was obtained. The effect of the contact stress between two YSZ single crystals, however, was not considered in those studies.

Not only grain boundary, but also oxygen-ion transfer at every interface, e.g. between electrolyte/electrode in SOFC, is an important issue. In most cases, an interface is subjected to contact stress (pressure); however it has not been quantitatively considered. For assessment of the oxygen-ion transfer at an interface under various contact stresses, a testing method should be established.

In the present study, first, oxygen-ion transfer between yttria-stabilised zirconia single crystals was investigated under mechanical contact stress. Two YSZ single crystal plates were piled up between platinum meshes, and contact stress was mechanically applied as shown in Fig. 1. The interfacial conductivity as well as the bulk conductivity was successfully measured with this setup.

As shown in Fig. 2, the interfacial conductivity is greatly influenced by the contact stress, whereas the bulk conductivity is almost independent of the stress. The interfacial conductivity is significantly increased with increasing the contact stress, whereas the interfacial capacitance also increases with the contact stress. The activation energy for the interface conductivity is 105 – 111 k J/mol, and appear to change slightly. The reason for change of the interface characteristics with the contact stress is under discussion. The most reasonable explanation for the increase of the conductivity with stress could be that an enlargement of the actual contact area between the YSZ plates could have increased the *apparent* conductivity; however, the contact stress increases only the interfacial conductivity almost without changing the bulk conductivity. The present experimental result therefore indicates that the observed increase of the conductivity could be not the *apparent* increase due to the enlargement of the contact area but an *intrinsic* enhancement due to the contact stress/strain between the YSZ plates, which requires detailed study.

The proposed method was also applied to estimate interfacial characteristics between YSZ electrolyte and LSCF (La-Sr-Co-Fe-O) cathode. The interfacial characteristics between YSZ/LSCF under various stresses were successfully obtained.

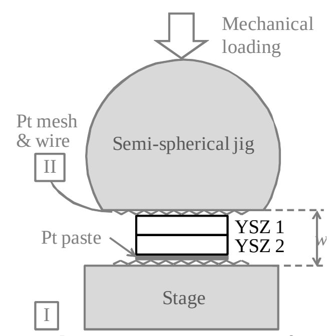

Fig. 1 Impedance measurement of YSZ/YSZ under mechanical contact stress

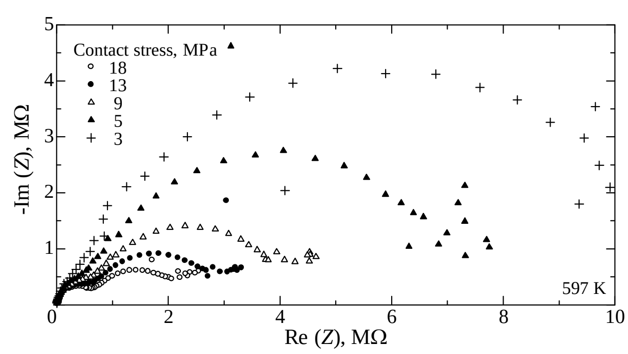

Fig. 2 Impedance plot of YSZ/YSZ measured under various mechanical contact stresses