Proton-Conducting Oxide and Applications to Hydrogen Energy Devices

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Ion-conducting solids are useful for sensing, mass transport, and energy conversion. For example, secondary batteries, fuel cells, and etc., utilize ion conduction in solids effectively to convert chemical energy to electrical one. Gas sensing is of another importance for controlling energy devices and ensuring safe operation. We should pay attention to the fact that these materials need electrochemistry to work, i.e., electrochemical cells are the essential mechanism. For example, water electrolysis is an electrochemical process many people are familiar with, but we should notice that it can proceed only in electrochemical manner; in the other cases, the water splitting is not a spontaneous reaction and will never proceed under ordinary conditions.

On the other hand, increasing emission of carbon dioxide, a major green-house-effect gas other than water vapour in the air, is a serious problem for the sustainability of human beings. We should change the primary energy source from fossil fuel to the so-called renewable energies, such as solar energy and wind energy. In addition, the reducing reliability and controversy of nuclear power these days give more reason for the introduction of these renewable energies. The use of these energies, however, needs efficient methods of energy storing and restoring, since the sun is not always shining and winds change every moment. “Hydrogen energy system” (Fig. 1) provides an effective conversion between the electricity and the chemical energy of hydrogen, and will be a possible solution for the energy management.

This paper describes the ion conducting materials suitable for hydrogen energy system. Since hydrogen is an important material and working as an energy medium in this system, hydrogen-ion-transporting materials are beneficial. Proton conducting oxides (Fig. 2) [1] will work for this purpose and will be introduced, viewing from material designing, working mechanism, etc. Application of the proton conducting oxide materials to the fuel cells [2] and water electrolysis [3] is another topic, and how they work in principle for conversion between the electricity and chemical energy and how their performances could/can be improved will be discussed.

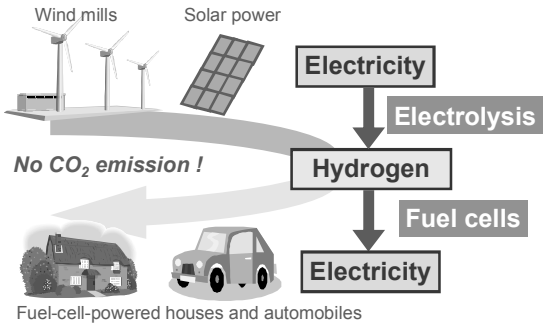

Fig. 1 A schematic illustrating hydrogen energy system based on sustainable energies.

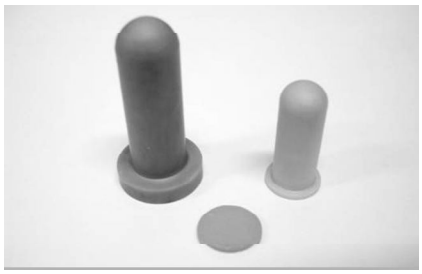

Fig. 2 Appearance of typical proton-conducting oxide: $BaCe_{0.9}Y_{0.1}O_{3-\alpha}$, $SrZr_{0.9}Y_{0.1}O_{3-\alpha}$.

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References

[1] H. Iwahara, T. Esaka, H. Uchida and N. Maeda, *Solid State Ionics*, **1981**, *3/4*, 359-363.
[2] H. Matsumoto, I. Nomura, S. Okada, T. Ishihara, *Solid State Ionics*, **2008**, *179*, 1486-1489.
[3] T. Sakai, et al., *Int. J. Hydrogen Energy*, **2009**, *34*, 56-63.