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Deposition of Crystallized Proton Conductive Oxide by RF Magnetron Sputtering

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1. Introduction

Solid oxide fuel cells (SOFCs) are considered to be one of the possible next generation energy systems because of its high electricity generating efficiency and low environmental impact. However, present high operating temperatures of SOFC around 800-1000℃ cause high apparatus costs and difficulty in the quick start-up, which prevents enlarging their applications, especially for the vehicle uses. Therefore, reducing operating temperatures lower than 600℃ is a key for solving these issues.

For this purpose, many studies on searching new materials which can reduce operating temperatures have been performed; however, it was quite difficult to reduce the operating temperatures dramatically. Thus, we focused on reducing electrolyte thickness because it is quite effective for reducing the operating temperatures. Thinning the electrolyte requires substrates with gas permeability and porous substrates are usually used, however, this makes depositing solid electrolyte thin films quite difficult.

In order to resolve this issue, we have proposed to use a proton conductive oxide deposited on palladium (Pd) plated porous stainless-steel (PSS) substrates as an electrolyte [1]. As the Pd layer, which possess hydrogen permeability, is fully covering the substrate surface, we can avoid the difficulty for depositing thin films on porous substrates. As the result, we can use varieties of deposition techniques of oxide thin films, such as Pulsed Laser Depositions (PLD), Sputtering, Sol-gel method, etc. We chose Y-doped $BaCeO_3$ (BCYO) as a proton conductive oxides in the point of views of proton conductivity. In this research, we chose Sputtering for fabricating BCYO thin film since comparatively easy to control composition ratio. We study the effect on crystallization of BCYO by varying sputtering pressures. However, PSS is damaged above approximately 700℃. Therefore, in this paper, we report the conditions to enhance the crystallization within range of possible to use the PSS.

2. Experimental

We adopt the RF magnetron sputtering as a deposition technique of BCYO. The BCYO films deposited on platinized silicon (Si) substrates using argon (Ar) as the sputtering gas. The deposition temperature was chosen between 400-600℃.The crystallinities of deposited films were characterized by the powder X-ray diffraction (XRD) using CuKα radiation.

3. Result and Discussions

Figure 1 shows the XRD patterns of BCYO thin films derived at sputtering pressures of 0.1 to 1.4Pa. All of the samples showed those of crystallized peaks which are identified as BCYO. As increasing sputtering pressures, crystallinity was degraded. This might be related to mean free path of sputtered BCYO. However, some of them showed secondly peaks identified as Y_2O_3, which suggests partially decomposition of BCYO. This different phase might cause degradation of a proton conductivity and we need to resolve this issue for the SOFC applications.

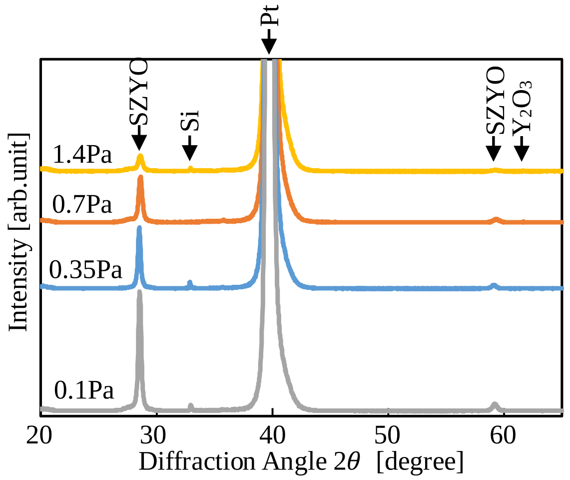

Fig. 1. XRD patterns of BCYO thin films at various sputtering pressures at a substrate temperature of 500℃.

4. Conclusions

We achieved crystallized BCYO as low as 500℃ by RF magnetron sputtering, especially in low pressure atmospheres. However, they showed Y_2O_3 secondly phase which might cause degradation of proton conductivity. In order to improve the crystallinity of BCYO, we need to examine the further effect of annealing conditions, etc.

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References

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