Deposition of Yttria Stabilized Zirconia (YSZ) Film on ZEOCOAT® Layer by Reactive Sputtering

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Introduction: Our research group has reported that yttria stabilized zirconia (YSZ) film is much effective to stimulate crystallization of amorphous silicon (a-Si) at low temperature and improves crystallinity of crystallized Si [1,2]. For application of YSZ film to flexible electronics with a plastic or organic substrate, deposition of YSZ on that substrate is necessary. Therefore, we tried to deposit YSZ film on ZEOCOAT® layer by reactive sputtering with Ar and O_2. ZEOCOAT® is a cyclo-olefein polymer with good electrical and thermal insulating properties and has potential application in flexible electronics, as it might be able to prevent heat damage of organic substrates. In this meeting, the characteristics of the YSZ films deposited on Zeocoat layer with/without a metallic film are presented and discussed.

Experimental procedure: YSZ films were deposited on ZEOCOAT® layers by reactive sputtering with or without a metallic film. The thickness of the metallic Zr deposited by Ar sputtering was varied from 1 to ~13 nm. For deposition of YSZ film, Ar and O_2 gases were used as sputtering and reactive gases, respectively. The deposition pressure was 6.8 mTorr. The flow rates of Ar and O_2 were 5.8 and 0.65 sccm, respectively. The sputtering power was 40 to 100 W and the deposition time was 10 to 20 minutes. The substrates were not intentionally heated. The crystallinity of the deposited films was examined by X-ray diffraction (XRD) technique.

Results and discussion: Figures 1(a) and (b) show the photographs of the YSZ films deposited on ZEOCOAT® layers without and with a metallic film of ~ 2 nm thickness. Nomarski microscope images of the surfaces at 50x magnification are also shown. The sputtering powers for (a) and (b) were 100 and 40 W, respectively. As can be seen from the photographs, the sample without metallic film exhibits a brown color while the one with the metallic film has a white-ish surface. From this result, reduction of sputtering power and depositing a metallic film on ZEOCOAT® layer seems effective to prevent ZEOCOAT® carbonization. We have also observed the same effect of a metallic film thicker than 10 nm. But, it was partially oxidized even after YSZ deposition and some metallic regions remained. After investigation, a thickness of the metallic film was chosen to be 1 nm. Figures 2(a) and (b) show the XRD patterns of YSZ films deposited on ZEOCOAT® layers without and with a metallic film, respectively. For this case, the sputtering power was 40 W and deposition time was 10 minutes. The thickness of the metallic film was 1 nm. The ideal peak position of YSZ(111) is about $2\theta = 29.8^0$. In Fig. 2(a), no significant peak position is observed. However, in Fig. 2(b), a very broad peak of characteristic YSZ(111) can be observed with a very small intensity. This may indicate a possibility to grow a crystallized YSZ film on ZEOCOAT® layer by using a thin metallic film.

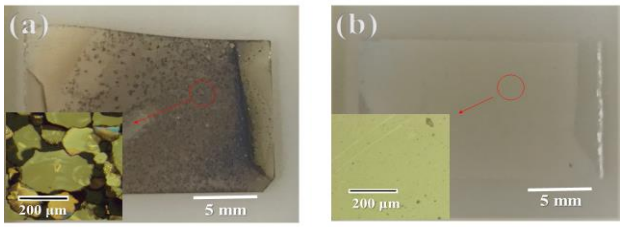

Figure 1 Photographs of YSZ films deposited for 10 minutes (a) directly on ZEOCOAT® at 100 W, and (b) on a 2-nm-thick metallic film on ZEOCOAT®at 40 W. The insets show Nomarski microscope images of the film surfaces at 50x magnification.

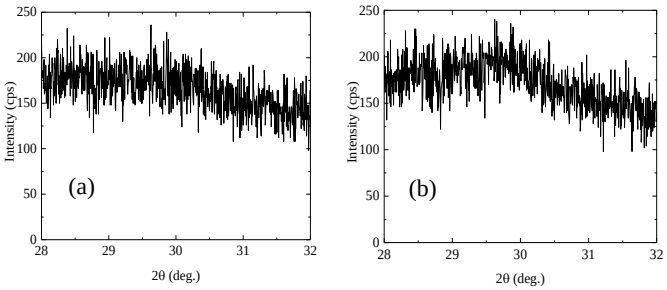

Figure 2 XRD patterns of YSZ samples deposited at 40 W for 10 minutes (a) directly on ZEOCOAT®, and (b) on 1-nm-thick metallic film on ZEOCOAT®.

Summary: From this experiment, it was found that a very thin metallic film on ZEOCOAT® was effective to prevent carbonization of the polymer. In the presentation, investigation results on improvement of YSZ crystallinity will be shown in detail.

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References: [1] Mai Thi Kieu Lien and Susumu Horita, Jpn. J. of Appl. Phys. **53** (2014) 03CB01.
[2] Mai Thi Kieu Lien and Susumu Horita, Jpn. J. of Appl. Phys. **54** (2015) 03CA01.