Deposition of Crystallized Yttria Stabilized Zirconia (YSZ) Films on Cellulose Nanopaper (CNP) Substrates at Low Temperature by Reactive Sputtering

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Introduction: Our research group has previously reported that yttria stabilized zirconia (YSZ) film is quite effective to stimulate crystallization of amorphous silicon (a-Si) at low temperature. A crystallized YSZ film can be deposited on a non-heat resistive cellulose nanopaper (CNP) substrate without any damage using DC magnetron sputtering with Ar and O_2, which indicates a high possibility to fabricate a poly-Si TFT on CNP [1]. CNP has been a promising substrate for fabrication of eco-friendly, cheap and flexible electronics [2]. Previously, we have reported pre-sputtering and sputtering conditions to deposit crystallized YSZ on glass substrates [3-4]. In this meeting, we further discuss deposition parameters and YSZ crystallization process on CNP in detail. Also, we discuss damage of CNP due to heat and plasma during the deposition process.

Experimental procedure: The sample structure is shown in Fig. 1. A Zeocoat® (thermal buffer layer), and a SiO_x layer using PHPS (perhydropolysilazane) solution were coated on a slide glass covered with a CNP layer continuously. The curing temperature and time for both Zeocoat® and SiO_x layers were 100°C and 1 hr, respectively. For the YSZ film deposition, the mass flow rate of Ar F_{Ar} and O_2 F_{O2} were 19.3 sccm and 0.8 sccm, respectively and atomic ratio of Y in YSZ, R_Y = Y/(Y+Zr) was 0.18. Sputtering pressure, power, and time was 6 mTorr, 100 W, and 10 min respectively. The substrate temperature monitored by thermo-label attached on holder side was always less than 80°C during the YSZ film deposition. The crystallinity of deposited films was examined by X-ray diffraction (XRD) technique and the damage to CNP was estimated by UV spectroscopy.

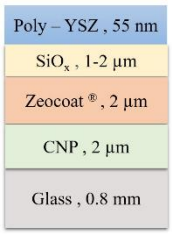

Fig. 1. Sample structure.

Results and Discussion: Figure 2 shows the XRD patterns of the YSZ films on CNP under the three different conditions of R_Y, F_{Ar}, F_{O2}, and P. It is very clear that degree of crystallization strongly depends on the deposition conditions which will be discussed in the meeting in detail. Figure 3 shows the internal absorbance A_i of each layer in the sample where the YSZ film was deposited with the optimum conditions for YSZ crystallization. It is evident from Fig. 3 that there is almost no damage after coating and curing of both Zeocoat® and SiO_x layers. A little increase in A_i after YSZ deposition is due to internal absorbance of YSZ film, which is the same as absorbance of YSZ film itself deposited on glass without CNP. Therefore, from this results we confirm the deposition of crystallized YSZ on CNP without any damage to substrate.

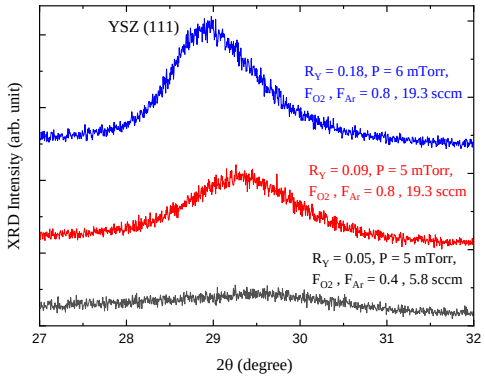

Fig. 2. XRD patterns of YSZ films for different deposition conditions.

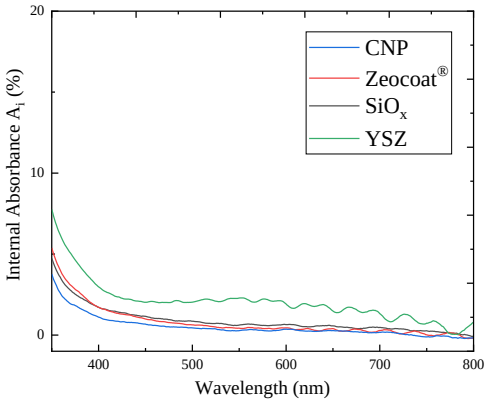

Fig. 3. Internal absorbance spectra of the sample.

Summary: We deposited crystallized YSZ film without any damage to CNP. In the meeting, YSZ deposition conditions and crystallization mechanism at low temperature will be discussed in detail.

References: [1] S. Horita, JSAP 65th Spring, 2018, 20a-C103-1.
[2] Y. Fujisaki et al., Adv. Funct. Mater. 24 (2014),1657.
[3] J. Patidar and S. Horita, JSAP 80th Autumn, 2019, 21a-C310-7.
[4] J. Patidar and S. Horita, JSAP 67th Spring, 2020, 15a-PB1-1.