Enhanced Crystallization of Ferroelectric Lead Zirconate Titanate (PZT) Ultra-thin Film by Solution-Combustion Synthesis Method with a Lead Titanate (PTO) Seeding Process

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Nowadays, as the scale-down trend for the semiconductor devices is getting dominant in the industrial applications, to obtain device-quality thin film under a minimized thickness is getting increasingly popular, especially for the widely applied ferroelectric PZT thin film. However, to obtain well crystallized perovskite ferroelectric PZT thin films, a high crystallization temperature (>600 ^{o}C) is normally required, which makes it incompatible to be integrated with high density complementary–metal–oxide–semiconductor (CMOS) devices where low processing temperature (<450 ^{o}C) is highly desired [1]. The integration of low processing temperature and the high crystallinity for ultra-thin PZT film still has been less explored.

From the previous study, hundreds-nanometer-thick crystallized SCS-PZT thin film has been realized by solution-combustion synthesis (SCS) method under low temperature [2]. However, this thickness is too large resulting in a limitation for further applications, for example, ferroelectric tunneling junctions. Previously, I proposed the SCS approach with a PTO seeding process to obtain perovskite PZT thin film at the primary stage at a low temperature (400 ^{o}C) at an ultrathin thickness (37 nm) [3]. For obtaining better crystallized PZT thin film, stacking layers is normally applied. However, this measure contradicted with the fact of high demanding of ferroelectric ultrathin film.

Here in this study, I have improved the crystallization of the ultrathin SCS-PZT film with a thickness of less than 40 nm through solution-combustion synthesis method with a lead titanate (PTO) seeding process at 450 ^{o}C. The perovskite PZT crystallization was investigated by scanning electron microscope (SEM, Hitachi SU8000). As shown in Fig.1, from the SEM images of 3-layered SCS-PZT thin film with and without seeding process, it could conclude that the introduction of a seeding process could realize a higher crystallinity and denser final SCS-PZT ultrathin film without increasing the film thickness. Further characterizations will be added including the X-ray Diffraction and Polarization-Electric field hysteresis measurement to discuss the crystallization state and ferroelectric property respectively.

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(a) (b)

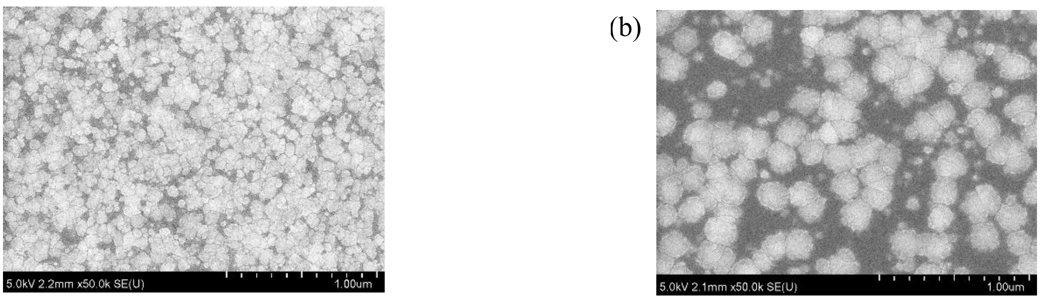

Fig. 1. Top-view SEM images of the 3-layered SCS-PZT thin-films processed under 450 ^{o}C: (a) with and (b) without the PTO seeding process.