CSD-derived Ferroelectric and Dielectric Thin Films –Molecular-design for Properties-

Hisao SUZUKI
Graduate School of Science and Technology, Shizuoka University
3-5-1 Johoku, Naka Ward, Hamamatsu, 432-8561, Japan
tchsuzu@ipc.shizuoka.ac.jp

ABSTRACT :

Chemical solution deposition (CSD) is the smart and cost effective processing method for advanced materials and thin films. For the smart chemical processing of thin films and nanoparticles by the CSD, molecular design of the precursor is essential. In this study, the importance of the molecular design for the chemical processing is focused on the orientation and residual stress control of the ferroelectric thin films and the crystallization control of the dielectric nanoparticles. For the orientaiotn and residual stress control of the ferroelectric thin films, we designed the molecular structure of the oxide thin film electrode of lanthanum nickel oxide, $LaNiO_3$ (LNO), which acted as a seeding layer for the orientation control. Namely, we used large side chain groups for the LNO precursor solution to control the film orientation and the residual stress of the ferroelectric thin films, by introducing the nanopores in the LNO layer on a Si wafer to relax the tensile constraint force from a Si wafer.

As a result, tensile stress from a Si substrate with very low coefficient of thermal expansion (C.T.E.) was successfully relaxed with increasing LNO thickness to increase the residual compressive stress in the ferroelectric thin film on a Si wafer, because LNO has a higher C.T.E. than those of the typical ferroelectric materials. The introduced compressive strain for the ferroelectric thin film will lead to the following effects; (1) Curie temperature shift towards the higher temperature, (2) Morphotropic phase boundary shift in the case of $Pb(Zr_X\ Ti_{1-X})O_3$ (PZT), and (3) Enhanced electrical properties. In this study, these effects were experimentally elucidated for the PZT and $BaTiO_3$ thin films.

The other example for the importance of the molecular design is the effect on the crystallization of alumina nanoparticles. As you know, low-temperature deposition of the corundum nanoparticles is very difficult. Therefore, we design the molecular structure of the oligomer from aluminium alkoxide to increase the six folded AlO_6 octahedron in the precursor. As a result, corundum nanoparticle was successfully obtained at above 773 K with a help of nano-seed. Such a molecular design will lead to the low-temperature deposition of a dielectric sapphire thin film on a Si wafer as a new class of commercially used substrate.