Impact of low pressure consolidation annealing on electrical properties of sol-gel derived $Pb(Zr,Ti)O_3$ films

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$Pb(Zr,Ti)O_3$ (PZT) thin films have been most extensively studied for nonvolatile ferroelectric random access memory (FeRAM) applications. In this work, we demonstrate that drastic improvement of electrical properties of sol-gel derived PZT thin films can be obtained by low-pressure consolidation annealing.

PZT thin films have been prepared on $Pt/Ti/SiO_2/Si$ substrates. First, source solution of $Pb_{1.2}Zr_{0.4}Ti_{0.6}O_3$ was spin-coated and dried at 240°C in air. After the spin-coating was repeated for several times, the samples were annealed at 400°C for 10 min at 35 Torr for consolidation. Next, the consolidated films were annealed at 480-600°C for 15-30 min in O_2 for crystallization. The film thickness was varied from 40 to 140 nm.

It is found that low-pressure consolidation annealing drastically improve electrical properties of PZT films. A remanent polarization (Pr) of 35 $\mu C/cm^2$ with a coercive filed (Ec) of 64 kV/cm was obtained for the PZT film crystallized at 600°C with low-pressure consolidation process. Even when the crystallization temperature is reduced to 520°C, a Pr of 33 $\mu C/cm^2$ was obtained for the PZT film fabricated with low-pressure consolidation. On the other hand, Pr and Ec of the PZT film fabricated by the conventional sol-gel process (crystallized at 600°C) using the same source solution are 19 $\mu C/cm^2$ and 83 kV/cm, respectively. Furthermore, leakage current density of the PZT film fabricated with low-pressure consolidation process is about two orders of magnitude lower than that of the film fabricated by the conventional process. Drastic change is also found for the grain size. The grain size of PZT films fabricated with low-pressure consolidation is as small as 150 nm, whereas that of PZT films fabricated by the conventional process is as large as 1.5 μm. It is considered that the low-pressure consolidation makes more nuclei in the films before the crystallization.