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Invited

Atomically Controlled Formation of Dielectric and High Tc Oxide Thin Films by Laser Ablation

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1. Advantages of laser ablation method for the synthesis of metal oxide thin films.

Laser ablation method is suitable for the formation of metal oxide thin films, such as dielectric materials and high Tc superconductors. This is because laser beam comes from outside of the film formation chamber and therefore oxygen pressure can be chosen as a desired value for the growth of thin films. Fig.1 shows a schematic diagram of laser ablation system used for the experiment. Emission of atoms and ions only from the irradiated targets gives a non-contaminated pure thin films on the substrate which are suitable for the device application. Internal excess energy and kinetic energy ranging from 10 to 100eV of emitted atoms and ions by laser ablation also assist the migration of atoms on the substrate surface leading to the low temperature formation of thin films.

2. High dielectric constant thin films

Fig.2 shows D-E hysteresis curve of $PbTiO_3$ thin films formed by laser ablation. Clear hysteresis is observed, and the value of remanent polarization is 80 μC which is almost the ideal value of

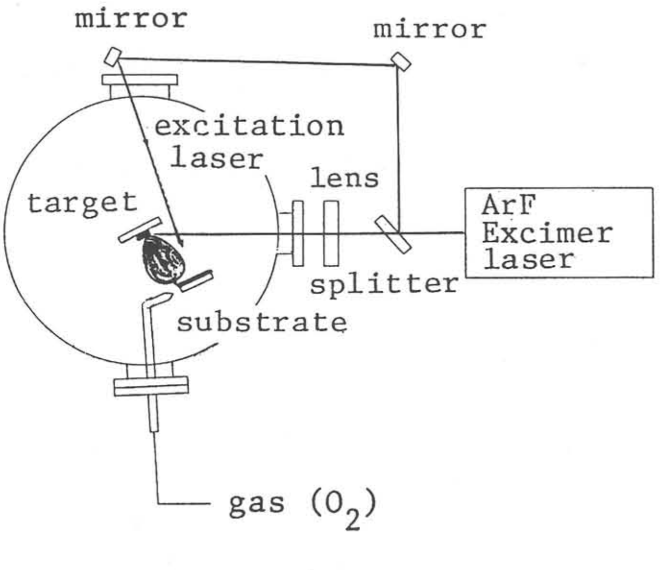

Fig.1 Laser ablation system

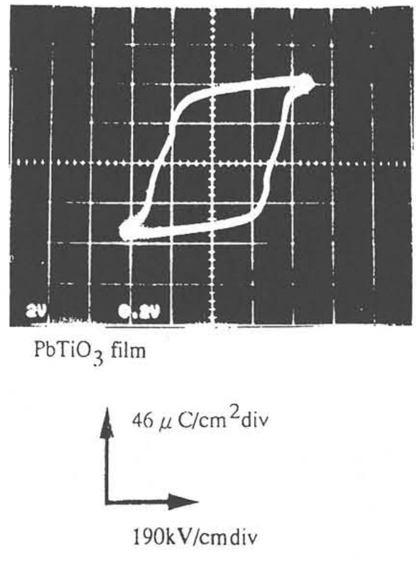

Fig.2 D-E hysteresis curve of the $PbTiO_3$ thin film

PbTiO3. This high quality c-axis oriented film is obtained by rapid cooling of the film after deposition utilizing the lattice mismatch between the substrate and the film to enhance the c axis orientation. Second laser irradiation during the film formation with delay time of 6 μ sec also enhances the crystallinity and assists the low temperature formation of the films. Table 1 summarizes the properties of the dielectric and ferroelectric thin films of $PbTiO_3$, $BaTiO_3$, $SrTiO_3$ and $CaTiO_3$ fabricated by laser ablation method.

3. Molecular layer control of dielectric strained superlattices

As shown in Fig.3, the strained superlattice is formed by the stacking of SrTiO3 and BaTiO3 layers which have different lattice constants. This superlattice shows high dielectric constant at the short stacking periodicity of each layer. It is noticeable that the $(Sr_{0.3}Ba_{0.7})TiO_3/(Ca_{0.3}Sr_{0.7})TiO_3$ strained superlattice exhibits the dielectric constant of 900 even for the film thickness of 500A. This result indicates that the strained superlattice approach is one of the promising ways for the fabrication of ultra-high density DRAM.

4. Atomic layer control of high Tc oxide thin films

High Tc superconductors have been fabricated by atomic layer deposition method to create new superconductors using the laser MBE method shown in Fig.4. RHEED and STM are used for the control of the growth of atomic layers, and superconducting Ba-Ca-Cu-O as well as Au-Ba-Cu-O artificial superlattices have been synthesized for the first time. Fig.5 summarizes the basic concept of superconducting artificial lattices.

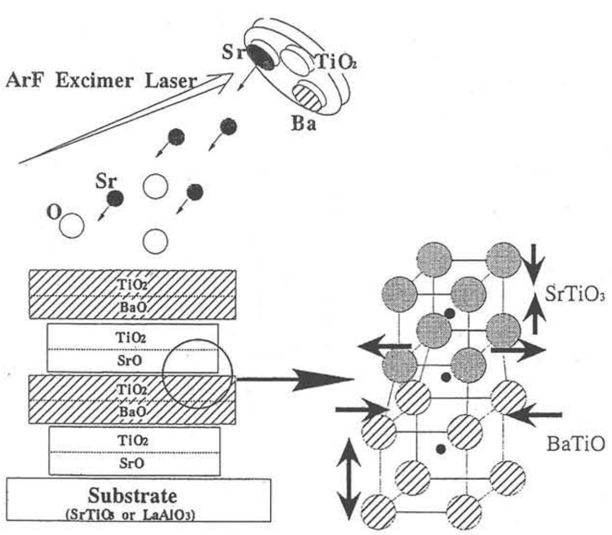

Fig.3 Schematic diagram for the formation of $SrTiO_3/BaTiO_3$ strained superlattices

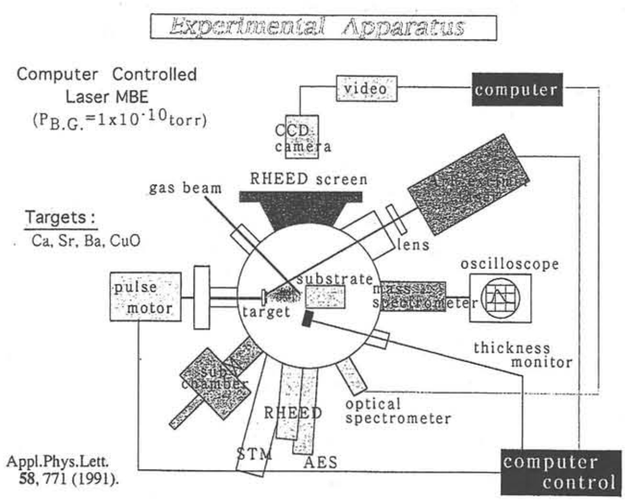

Fig.4 Laser MBE apparatus

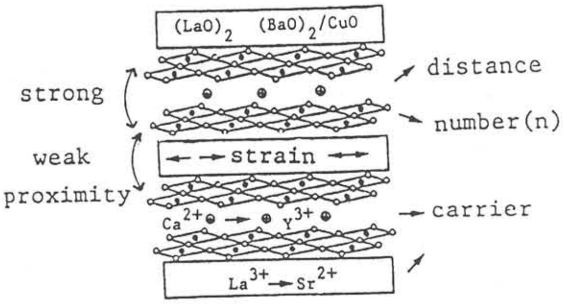

Fig.5 Scheme of superconducting artificial lattices

	$PbTiO_3$	$BaTiO_3$	$SrTiO_3$	$CaTiO_3$
lattice constant c	4.14Å	4.04	3.91	3.82
lattice constant a	3.90	3.99	3.91	3.86
FWHM	0.3°	0.13	0.12	0.15
orientation	c-axis	c-axis	c(a)-axis	c-axis
dielectric constant (ideal value)	120-130 (100)	400-450 (400)	280-300 (300)	100-120 (150)
spontaneous pol. (ideal value)	80 $\mu C/cm^2$ (81)	15-16 (25)	dielectric	dielectric

Table 1 Dielectric and ferroelectric properties of thin films