Journal Paper review (MSE631A)

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New Ferroelectric Material for Embedded FRAM LSIs

This paper is about the use of ferroelectric materials in memory devices (ferroelectric random access memory-FRAM) where Secure, high speed, and low power consumption nonvolatile memories are required. These devices are used with smart RFID tags and secure IC cards (i.e. personal authentication e-services). In this review paper we will talk about the use of FRAM over other conventional devices and we will introduce new ferroelectric material that will enable us to fabricate FRAM in a 90-nm technology node.

Because of ideal memory properties, such as very low power consumption and high-speed read/write performance, FRAM has been applied to LSIs (Large-Scale Integration) for IC cards, RFID tags, smart cards, and for alternate memory addressing with battery backup. In order to expand their applications some changes in the stoichiometry of these ceramics has been made which increases memory capacity, reduces operating voltage, and increases the read/write cycles.

PZT ($Pb(Zr,Ti)O_3$) is used in FRAMs but it has limited remnant polarization ie low storing capacity. It does not have enough switching charge for 90-nm technology node because its fabrication through semiconductor process restricts that. A method has been suggested to overcome this problem by expanding the surface area by assembling a capacitor into a 3D structure but that is also challenging because to get enough switching charge we have to arrange the crystal orientation completely which is itself a difficult task.

A new ferroelectric material, BFO ($BiFeO_3$) for a 90-nm technology has replaced use of PZT. In BFO some of the Fe ions are substituted with 5% Mn ions which decreases the leakage current in the BFO film at room temperature and increases the withstand voltage. With the use of BFO, 5 times larger switching charge is achieved and leakage current is also reduced thus overall memory capacity of device increases. It has been shown that the relative dielectric constant of BFO is one-fourth to that of PZT, and its Curie temperature is 800°C, which is very higher than that of the conventional material. Thus, these properties makes BFO work at high-speed read/write and high-temperature operations and makes them one of the important material in this industry.

Some methods for further improvements in storing capacity of BFO has been discussed. These mainly include reducing of operating voltage, low temperature deposition of BFO film and selection of passivation film to prevent Fe diffusion. With implementation of these techniques BFO has a great potential to serve this industry with much more higher storing capacity.