Modulation of magnetic properties of magnetic thin films using flexible and ferroelectric substrates

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論 文 名　:　Modulation of magnetic properties of magnetic thin films using flexible and ferroelectric substrates
(柔軟で強誘電性の基板を使用した磁性薄膜の磁気特性の変調)

区　　分　:　甲

論 文 内 容 の 要 旨

Electric-field manipulation of magnetic properties in multiferroic heterostructures is considered an optimistic way of authorizing memory and magnetic microwave devices with ultralow power consumption. Recently, Multiferroic materials which possess both ferroelectricity (FE) and ferromagnetism (FM) provide a simple and effective way to realize electric field control of magnetism through the converse ME coupling effect, i.e electric field control of magnetism without the need for magnetic fields.

In this Ph.D. thesis two main topics were discussed

1- The magnetic and magnetostrictive properties of FeSiB Film on two different substates Fz:Si and Polymide.

2- The magnetoelectric properties of the multiferroic heterostructure FeSiB/PMN-PT.

In orde rto study the magnetoelectric properties of a FM/FE multiferroic heterostructure, we have chosen FeSiB as a FM layer. Generally, Amorphous FeSiB thin films presenting magnetostriction have been investigated for decades for energy and sensors applications. They are very soft magnetic films, with high magnetization saturation.

For better understand of our chosen FM layer properties, we first studied the statics and dynamics magnetostrictive properties of the amorphous Fe72Si14B14films with different thicknesses on two different substates Fz:Si and Polyimide(with different curvatures)to confirm the magnetic and magnetostrictive properties of FeSiB. Then, we studied the magnetoelectric (ME) properties of the multiferroic heterostructure by depositing the FM magnetostictive Fe72Si14B14 amorphous film with a wide range of thicknesses (10,20,50 and 100 nm) on the top of piezoelectric substrate PMN-0.3PTby Dc sputtering technique. After that Ferroelectric, magnetic and ME properties were studied through static and dynamics measurements.

Obtaining the magnetoelectric coupling in multiferroic heterostructures mainly focuses on three mechanisms including strain mediated, charge carriers, and exchange bias. The most investigated and well-known mechanism is the strain mediated, in which the electric field produces strains inside FE layer which transferred to the FM layer by convert magnetostrictive effect, resulting in high electric field tunability of the magnetic properties of the examined structures. On the other hand, in the charge mediated mechanism, electric field induce charge

mediated coupling across FM/FE interfaces also adjusts the charge carrier concentrations at the FM layers via an accumulation or depletion process depending on the direction of FE polarization. it seems that the coexistence of more than one mechanism that can contribute to controlling the magnetism in multiferroic heterostructure is a good way that could lead to significantly enhanced ME coupling in multiferroic heterostructures.

More recently, it has been reported that the charges at the magnetic-FE interface can also act as a medium that couples electric-voltages towards modulation of magnetism, either through the electrostatic accumulation of spin-polarized charges orby purely electronic origins, such as the interfacial orbital hybridization and the interfacial orbital reconstruction

We obtained high, non-volatile, irreversible and thickness dependent changes in the magnetic properties of FeSiB films. The high Electrical tunning of the magnetic properties of our studied heterostructures were understood through stain and charge co-mediated mechanisms, which is the interaction between two relating coupling mechanisms that are the interfacial strain and possibly the charge effects. From our results also we confirmed that, charge effects may become remarkable only when the thickness of the magnetic film and/or the heterostructure becomes small.