ELECTRICAL FIELD CONTROL OF FERROMAGNETS USING MULTIFERROICS

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Complex perovskite oxides exhibit a rich spectrum of functional responses, including magnetism, ferroelectricity, highly correlated electron behavior, superconductivity, etc. The basic materials physics of such materials provide the ideal playground for interdisciplinary scientific exploration. Over the past decade we have been exploring the science of such materials (for example, colossal magnetoresistance, ferroelectricity, etc) in thin film form by creating epitaxial heterostructures and nanostructures. Among the large number of materials systems, there exists a small set of materials which exhibit multiple order parameters; these are known as multiferroics. Our goal is to be able to deterministically control the state of a ferromagnet with the application of an electric field, by using heterostructures that include multiferroic perovskites. Our model multiferroic is $BiFeO_3$, which has ferroelectric and antiferromagnetic order well about room temperature. We use a combination of laser MBE and chemical vapor deposition to create our model heterostructures. The magnetic and ferroelectric structure are probed using a combination of piezoforce microscopy, conducting AFM, photoemission spectromicroscopy and optical techniques. We have discovered that the ferroelectric domain structure significantly influences the coupling between the multiferroic and the ferromagnet. Even more interesting is the observation that certain types of domain walls are conducting, relative to the bulk material, primarily as a consequence of the change in the electronic structure at the wall.

Our work so far has shown that the AFM order can be controlled through coupling with the ferroelectricity. The next step is to explore the coupling of a ferromagnet to this antiferromagnet through the exchange biasing concept. Ultimately, this will give us the opportunity to switch the state of a ferromagnet (and therefore the spin polarization direction) by simply applying an electric field to the underlying antiferromagnetic ferroelectric. Preliminary results appear to be quite promising. In this talk, I will describe our progress to date on this exciting possibility.