Introduction

There is now an interest in using the spin of electrons as a key characteristic in electronic devices. Thus, instead of reading the charge, or voltage, to determine a one or zero for a signal, devices would read the spin, translating up or down into on or off. This use of spin in electronics is called *Spintronics*, and it has two main advantages over conventional electronics. First, it is faster, and second, it consumes less energy. These advantages are obviously extremely significant, and thus research is being done to make this technology possible.

The first step in creating spin-based electronics is to be able to have a spin-polarized source of electrons, having all the electrons having the same spin. Obviously, one cannot have an electronic system if he cannot control whether things are "on" or "off." This can be done in one of two ways. The first is to inject electrons directly from a conductor that is spin polarized. The second is to filter spins by tunneling electrons through a spin-polarized insulator. This second method was chosen for this research.

As aforementioned, the method that has been chosen for creating a source of spin polarized electrons requires a spin-polarized, ferromagnetic, insulator. The term 'ferromagnetic' means that all the spins are aligned. Europium Sulfide (EuS) has been chosen for multiple reasons. First, it was the first discovered ferromagnetic insulator and has been extensively characterized. Second, it has an extremely large band splitting of 0.37eV. The band splitting refers to the difference in energy levels of the tunneling barrier for the two spins states of electrons (Figure 1). Essentially, since EuS is ferromagnetic and it has seven valence electrons on the Eu^{2+} ion, it has an extremely large internal magnetic field. This field causes a Zeeman effect, which causes the tunneling barrier to split in two, one for each spin. In this case, the effect is enormous. This seemingly small number (0.37) is actually tremendous because the tunneling probability is exponentially proportional to the barrier size.

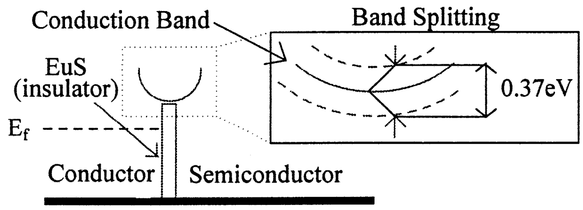

Figure 1 - Band Splitting in EuS

Research

This research was performed at Florida State University in the summer of 2000 and was funded by the National Science Foundation through the Research Experience for Undergraduates program. The purpose of the research was to grow sufficient thin films of EuS that could be used as spin filters. This was attempted through several unconventional growth means. By unconventional, it is meant that these techniques had not previously been attempted with EuS.

EuS was fabricated through a chemical reaction between Eu_2O_3 and H_2S. Bulk samples were prepared and characterized with respect to their structural and magnetic properties to confirm their purity. These characterizations were performed through x-ray diffraction and magnetic measurements with a superconducting quantum interference device (SQUID). These confirmed that the samples had the same characteristic critical temperature, structure, and ferromagnetic properties as EuS, and were therefore highly pure EuS samples.

These measurements also led to the stunning discovery that EuS has a saturation moment of $6.8\mu_B$, where it is expected to have 7 due to the seven valence electrons which give it it's ferromagnetic properties. These samples were compared to standard samples, and multiple measurements were taken on multiple SQUID's. An explanation for this has not been found, but it is currently thought to be some intrinsic property of EuS.

Thin film growths were then attempted through a few means. These included thermal evaporation of EuS in a crucible onto a substrate, and thermal evaporation in an evacuated quartz tube. These methods provided insufficient temperatures to cause evaporations. The failure of these methods led to the suggestion of sputtering EuS onto a substrate or sputtering Eu_2O_3 onto a substrate and then reacting the film to form an EuS film.

This research did not succeed in producing thin films, but it did form a method for producing and characterizing bulk samples of EuS. An interesting property of EuS was also discovered, and possible thin growth means were ruled out. Some more methods have been conceptualized and are waiting to be tested.