HIGHLY EFFICIENT SPIN FILTERING OF BALLISTIC ELECTRONS IN HYBRID SPIN VALVE/SEMICONDUCTOR STRUCTURES

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Abstract

Efficient spin detection of photoexcited electrons at room temperature in single ferromagnetic (FM) layer/semiconductor (SC) Schottky barrier structures has recently been demonstrated in our group [1,2]. We find that the photocurrent is dependent on the relative alignment of the light helicity with the FM layer magnetisation and attribute this effect to the spin filtering of electrons at the SC/FM interface. In this lecture I first review our recent studies of photoexcited spin dependent transport and then discuss in detail the results of a recent investigation of a hybrid Au/Co/Cu/NiFe/n-GaAs spin valve Schottky barrier structures, where the two FM layers can be switched independently. Circularly polarised light of various wavelengths, modulated with a photoelastic modulator, was used to excite spin polarised electrons in the GaAs at room temperature, and the helicity dependent photocurrent across the spin valve/SC structure was measured using a lock-in amplifier. A 2400% increase in helicity dependent photocurrent was observed when the spin valve was switched from parallel to antiparallel alignment, clearly ruling out a simple superposition of spin filtering at the SC/FM interface and conventional GMR. Furthermore the spin valve/SC structure enabled us to separate the photocurrent across the SC/FM interface from the net measured photocurrent, allowing for the observed spin filtering effect to be quantified. In the antiparallel configuration the current spin polarisation P was found to be 5.9% for h=1.96eV. This shows that high energy electrons are spin filtered with a high degree of efficiency, taking into account the spin polarisation of the electrons photoexcited in the GaAs (10% [3,4]). Moreover the finding that only a small fraction of the photoexcited electrons (about 2.6%) propagates into the spin valve at zero bias proves that the spin filtering observed in previous studies [1,2] is artificially reduced due to electrons passing into the SC. The relative change in helicity dependent photocurrent between parallel and antiparallel spin valve alignment decreases rapidly with decreasing photon energy, suggesting that electrons passing over the Schottky barrier are involved in the spin filtering process. Our combined data provides clear evidence for highly efficient spin filtering of ballistic electrons propagating through the potential energy îlandscapeî of the spin valve structure. The finding that that a spin valve has the capability of detecting a small spin imbalance of the current flowing from the SC into the FM makes it a promising candidate for future spintronic devices.

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