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Technical Digest of

Frontiers in Electronic Materials

A collection of extended abstracts of the Nature Conference
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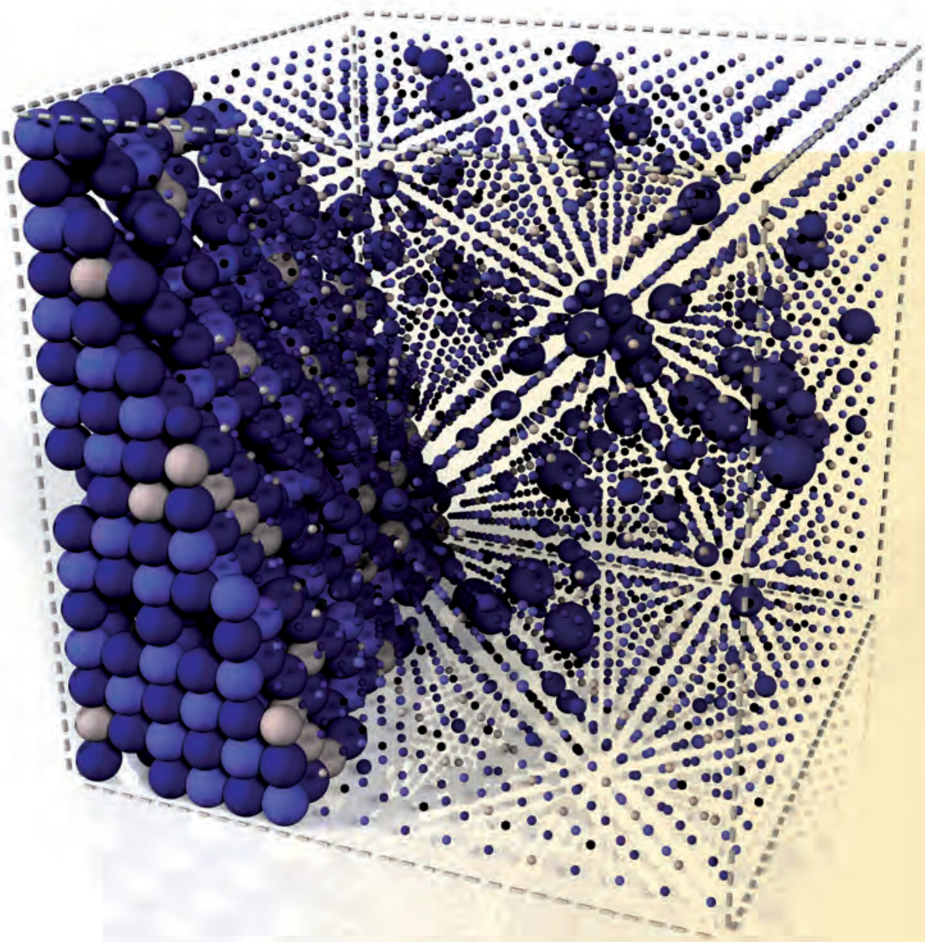

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SIT 2

ELECTRICAL SPIN INJECTION AND SPIN TRANSPORT IN ZINC OXIDE

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The wide bandgap semiconductor ZnO is interesting for semiconductor spintronics because of its small spin-orbit coupling implying a large spin coherence length. This is a prerequisite for the successful creation, transport, and detection of spin-polarized currents over hundreds of nanometers in typical spintronic devices. In this context, the spin dephasing time of mobile charge carriers - and the associated length scale for coherent spin transport - are fundamental parameters. While other semiconductors like GaAs and related III-V compounds have been studied extensively, only very few reports on the spin coherence in ZnO exist. Using time-resolved *optical* techniques, electron spin coherence at 30 K was observed in epitaxial ZnO thin films with a spin dephasing time of 20 ns [1]. Reports on *electrical* spin injection are rare [2,3] and focus on technical aspects like the improvement of GMR read heads rather than the fundamental spin-dependent properties of ZnO.

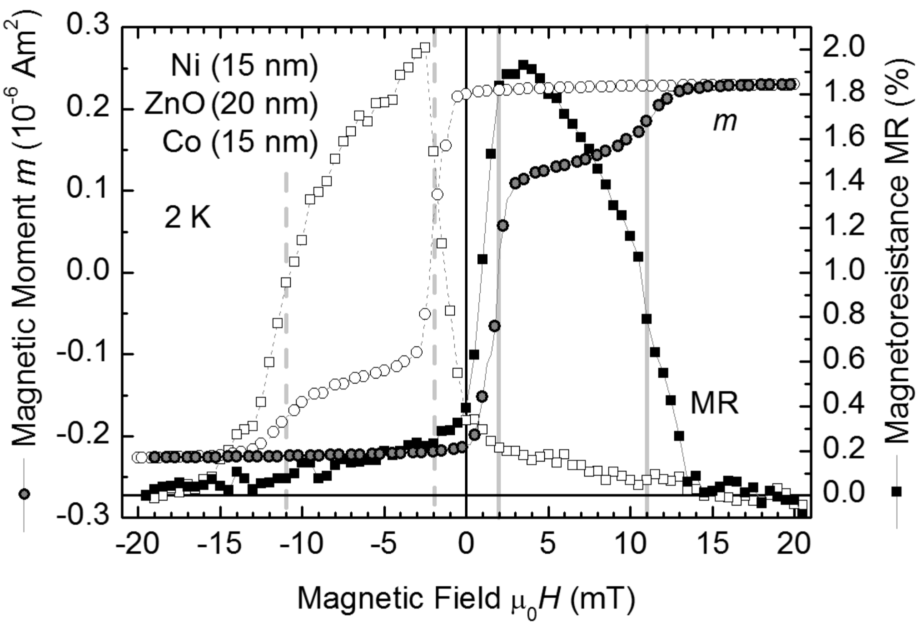

Figure 1: Magnetic moment *m* (circles, left axis) and magnetoresistance MR (squares, right axis) of a Ni/ZnO/Co spin valve device at 2 K as a function of the magnetic field *H* applied in-plane. Closed symbols represent data taken with increasing field, open symbols with decreasing field. The *m*(*H*) and MR(*H*) hystereses nicely correspond to each other with regard to their coercive fields (vertical grey lines), evidencing a spin valve behavior of the MR.

We investigate the injection, transport, and detection of spin-polarized charge carriers in ZnO utilizing all-electrical, vertical spin valve devices with ferromagnetic electrodes. Using pulsed laser deposition and electron-beam evaporation, we fabricated epitaxial multilayers of TiN/Co/ZnO/Ni/Au on (0001)-oriented Al_2O_3 substrates with different thicknesses of the ZnO spacer layer ranging from 5 nm to 100 nm. The multilayers were patterned into vertical mesa structures with junction areas between 100 μm^2 and 400 μm^2. Magnetotransport (MR) measurements with the magnetic field and the current applied in and perpendicular to the plane, respectively, show a clear spin valve behavior (Fig. 1). The switching fields correspond to the coercive fields of the ferromagnetic layers as determined by SQUID magnetometry (Fig. 1). For a ZnO thickness of 20 nm, the magnetoresistance (MR) increases from 0.8% at 200 K to 8.5% at 2 K (Fig. 1). We systematically analyze the maximum MR values as a function of the ZnO thickness in the framework of a two spin channel model with a spin-dependent interface resistance [4,5]. From our fits, we obtain spin diffusion lengths for ZnO of 12.3 nm (2 K), 9.2 nm (10 K) and 8.3 nm (200 K). This corresponds to a spin dephasing time of 110 ns at 2 K which exceeds previously published data determined from optical experiments. Here, we electrically create and detect a spin-polarized ensemble of electrons and demonstrate the transport of the spin information across several nanometers in ZnO.

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