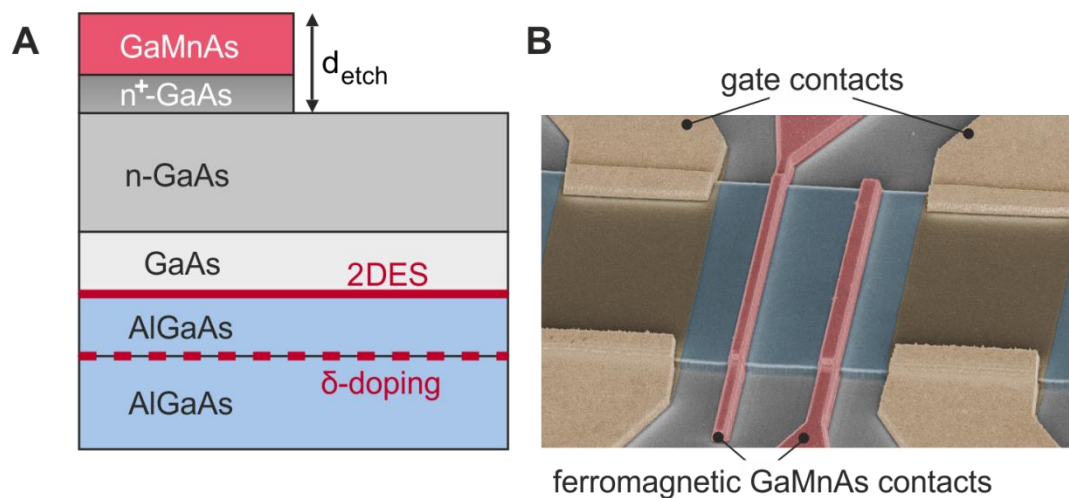


# Electric spin injection, detection and manipulation in two-dimensional electron systems

Dieter Weiss

*Institut für Experimentelle und Angewandte Physik, Universität Regensburg, D-93040 Regensburg, Germany*

Spin injection, spin manipulation, and spin detection in two-dimensional electron systems (2DES) is at the heart of semiconductor based spin transistor concepts [1]. Despite significant experimental effort during the last decades, spin-injection into 2DES showed discouragingly low spin signals  $\Delta R$  with  $\Delta R/R < 1\%$ . Here, I discuss our recent experiments on all electrical spin injection and detection in 2DES using (Ga,Mn)As/GaAs Esaki diode junctions (see Fig.1) as spin sensitive contacts [2], which show large spin signals with  $\Delta R/R$  up to 80% in standard spin valve geometry. In my talk I will focus on two-terminal measurements which show, in contrast to non-local measurements, strongly enhanced spin signals, ascribed to electric field effects at the detector [3]. Electric gates outside the current path in spin valve geometry (see Fig.1B), which enable switching between uni- and bipolar spin diffusion direction can be used to tune the spin signal electrically [3].



**Fig. 1:** **A)** Layout of the heterojunctions used for spin-injection/detection. Etching of the highly doped (Ga,Mn)As and  $n^+$ -GaAs layers depletes the bulk of electrons, thus enabling exclusive spin and charge transport in the 2DES. **B)** Device with ferromagnetic leads and non-magnetic gate contacts.

Work done in collaboration with Mariusz Ciorga, Martin Oltscher, Thomas Kuczmik, Franz Eberle, Andreas Bayer, Martin Utz, Dieter Schuh, and Dominique Bougeard.

## References

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