Longitudinally detected ESR (LODESR) using miniaturized Hall sensors

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We developed a LODESR spectrometer based on a miniaturized Hall sensor and a resonant cavity tuned at 14 GHz. We used InSb cross-shaped Hall devices (designed and fabricated in collaboration with Asahi Corporation) with active areas down to $(7\ \mu m)^2$. The Hall sensor is inserted in the cavity within a hole.
Coupling between the microwave power (guided wave) and the cavity is achieved by using an iris.We adjusted the iris diameter and the cavity dimension such that the resonant frequency is about 14 GHz. Our final design has a 4.36 mm diameter aperture. The Hall device does not significantly change the Q-factor and the resonance frequency of the cavity. The quality factor Q of the cavity is about 10^4.

The spectrometer can be used for either microwave amplitude or frequency modulation. The typical modulating frequency is about 50 kHz. The main static field B_0 is provided by a permanent magnet with a sweeping coil (6 mT sweep about a central magnetic field of 495 mT).
For a $(7\ \mu m)^3$ DPPH sample, the measured signal-to-noise ratio corresponds to a spin sensitivity of about 10^{10} spins/G√Hz (see figs.1 and 2). The measured noise is two orders of magnitude worse than the Hall device thermal noise limit (i.e. 2 nV/√Hz for our sensor having R=200 _). The origin of this noise is still not yet elucidated. Nevertheless, this result is better than most of inductive detected LODESR sensitivities reported to date.

References:

[1] M. Bouterfas, G. Boero, A. Skrivervik, J.-F. Zurcher, I. Shibasaki, R. S. Popovic, "Longitudinally detected ESR spectroscopy using miniaturized Hall sensor", App. Phys.Lett. in preparation (2005).
[2] G. Boero, P.-A. Besse, R. S. Popovic, "Hall detection of magnetic resonance", App. Phys. Lett. **79**, 1498 (2001).

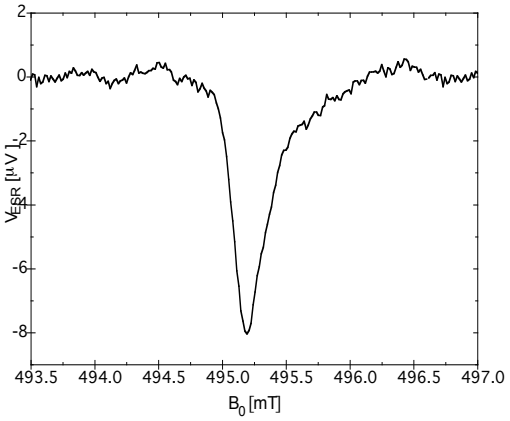

Fig.1: LODESR signal by field modulation obtained by a (7x7) μm² Hall sensor :
f_0= 14 GHz, f_m =54 kHz, number of averagings:4. The signal amplitude is about 8 μV and the noise 300 nV/Hz$^{1/2}$ which gives a spin sensitivity of 7_10^{10} spins/Hz$^{1/2}$.

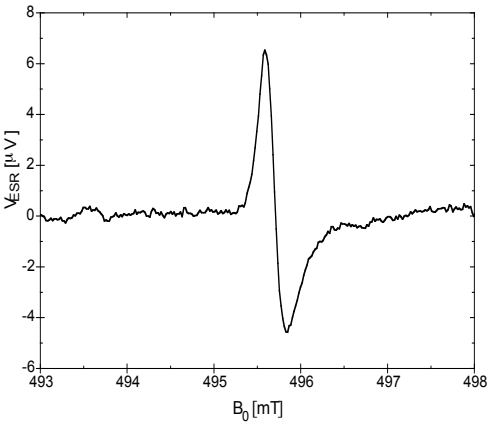

Fig.2: LODESR signal by frequency modulation obtained by a (7x7) μm² Hall sensor :
f_0= 14 GHz, f_m =54 kHz, number of averagings:4. The signal amplitude is 11 μV and the noise 80 nV/Hz$^{1/2}$ which gives a spin sensitivity of 1.5_10^{10} spins/Hz$^{1/2}$.