

Low temperature angle dependent VNA - FMR system for Spin-Pumping-Inverse Spin Hall Effect measurements

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Pure spin currents, generated via mechanisms like spin pumping and the spin Hall effect, facilitate the development of energy efficient electronic and memory storage devices [1]. Angle dependent ferromagnetic resonance (FMR)-spin pumping (SP) measurements provide a reliable method for separating parasitic microwave contributions from the measured voltage, allowing accurate determination of inverse spin Hall effect (ISHE) voltage. This, in turn, enables quantitative studies of spin-charge current conversion in a wide range of materials and accurate determination of their spin Hall angles [2].

We report the development of a low-temperature, VNA-FMR setup designed for angle dependent SP and ISHE measurements. The system employs a coplanar waveguide geometry covering a broadband frequency range up to 12 GHz and incorporates DC connections for simultaneous electrical detection of SP voltage. A quadrupole electromagnet with controlled rotation of in plane field enables systematic variation of both in plane and out of plane angles between the external magnetic field and the sample. Temperature dependent measurements are facilitated by a He-flow cryostat, allowing FMR and spin transport properties to be investigated from room temperature down to cryogenic regimes. The measurement setup is fully automated via LabVIEW. Test measurements done on Py and Py/SnTe samples demonstrate clear FMR absorption and well defined angle dependent ISHE voltage signals. Overall, this versatile low temperature VNA-FMR platform provides a robust tool for systematic investigations of angle and temperature dependent SP-ISHE measurements.

References:

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