11th International Conference
on Advanced Materials

Rio de Janeiro Brazil
September 20 - 25

ICAM2009

Spin Torque Oscillators

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Abstract – Spin Torque Oscillators (STO) is a novel class of extremely broadband frequency generators in the 1 – 100 GHz range. The STO uses spin torque to excite field- and current-tunable spin wave modes, either in extended films under a nanocontact or in fully patterned nanopillars. I will present our latest results on STOs based on both Giant Magnetoresistance (GMR) nanocontacts, and Magnetic Tunnel Junction pillars.

Interest in Spin Torque Oscillators (STOs) is rapidly increasing due to their potential use for microwave generation over large frequency ranges [1]. In these devices, the transfer of spin angular momentum between a spin polarized current and a thin magnetic layer [2,3] generates a precession of the magnetization, and as a consequence, oscillation of the device resistance, either through giant magnetoresistance or tunneling magnetoresistance. These devices are compact (~100 nm in lateral size), can be frequency tuned over tens of GHz, and typically exhibit a quasi-linear frequency dependence on both current and applied magnetic field. Additional frequency tuning can also be achieved by varying the angle of the applied magnetic field [4]. In particular, the frequency can be greatly increased, if the field direction approaches in-plane orientation. The possibility of much higher frequency operation is potentially attractive for a range of emerging micro- and millimeter-wave applications such as short-range high-speed radio links (IEEE 802.15.3c) around 60 GHz,15 and vehicle radar for active cruise control at 77 GHz [4].

In my presentation, I will report on measurements of the oscillation frequency of nanocontact based GMR-STOs as a function of current, magnetic field strength, and magnetic field angle. I will present the experimental observation of STO operation up to 46 GHz and extrapolations to 65 GHz. In addition, the detailed analysis of the angular dependence of the excited spin wave modes shows clear evidence of the coexistence of a propagating spin wave mode and a non-propagating spin wave soliton mode – a so-called spin wave bullet.

The STO can furthermore be frequency modulated (FM) to very high frequency. I will present FM data up to 3.2 GHz, with a power dependence agreeing very well with the standard Bessel behavior. However, beyond a certain critical modulation power, the classical modulation description seems to break down, and the STO modulation speed appears to be limited by its internal magnetodynamics.

I will also present data on nano-pillar based MTJ-STOs, with output power approaching 1 microwatt. The signal line width and the field and current dependence of the operating frequency allow us to separate the two spin torque terms relevant for MTJ-based STOs.

We gratefully acknowledge GMR-STO samples from Everspin Technologies and MTJ-STO samples from Seagate Technology. Financial support from The Swedish Foundation for strategic Research, The Swedish Research Council, the Göran Gustafsson Foundation, and the Knut and Alice Wallenberg Foundation is gratefully acknowledged. Johan Åkerman is a Royal Swedish Academy of Sciences Research Fellow supported by a grant from the Knut and Alice Wallenberg Foundation.

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