Spin-transfer-torque dependence on MgO tunnel barrier thickness in MTJs

W Skowróński 1, T Stobiecki 1, J Wrona 1, G Reiss 2, K Chalapati 3, G S Paraonu 3, S van Dijken 4
1 Department of Electronics, AGH University of Science and Technology, Krakow, Poland
2 Department of Physics, Bielefeld University, Universitätsstrasse 25, 33615 Bielefeld, Germany
3 Low temperature laboratory, Aalto University, P.O.Box 15100, FI-02015 Aalto, Finland
4 Department of Applied Physics, Aalto University, P.O.Box 15100, FI-02015 Aalto, Finland

Motivation
High density and fast MRAH can be implemented using current induced magnetization switching (CIMS) effect [1], caused by the interaction between spin-polarized current and local magnetization of the FL in the MTJ cell, called STT [2]. STT is also utilized in MTJ nanoscalators, that generate signals in the GHz frequency range when supplied with DC current [3].

Aim
To understand the STT effect in order to:
• reduce the critical current density in the CIMS effect
• optimize the MTJ parameters for memory technologies
• apply MTJ in microwave electronics

Sample description

A1. Deposition
• deposited using a Timaris PVD cluster tool system from Singulus Technologies
• linear dynamic deposition (LDD) wedge technology [4]

A2. E-beam lithography
• 3 step lithography process using e-beam lithography, ion milling, lift-off

A3. Wafer level characterization


B2. Setup
Spin-transfer ferromagnetic resonance (ST-FMR) measurement technique takes advantage of a DC voltage generated by a MTJ when supplied with a RF current [7, 8]:
• generation of the DC voltage $V_{mix}$ when the current frequency is in resonance $\omega$ with oscillations, arising from the STT
• the RF current was typically swept in the range of 2 - 12 GHz
• MTJ placed in an external magnetic field and at the certain angle, so that the angle $\theta$ between FL and RL during spin-torque diode measurement is fixed to 90°

Results and discussion

C1. Torques and torkances

• Parallel and perpendicular torkances derived from the ST-FMR signals
• Separate fitting procedure for each measurement with different DC voltage applied
• Torque numerically integrated from torkance

C2. Summary

• Parallel torque weakly depends on an applied DC bias voltage
• Absolute torque values increases with decreasing tunnel barrier thickness - consistent with a theory [9]
• Perpendicular torque amplitude measured in applied DC bias voltage range is max. 20% of the parallel one
• Strong coupling causes deviation from the theory

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