Nano-Point Contacts Processing for Spin-Torque Oscillators

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SPINSWITCH

Introduction & Aim

Nano-point contacts:

- GMR devices
- Access to magnetic layer through nano-contact.

Spin-transfer Torque: DC current induced

- Stable GHz free layer precession
  - Phase-locking mode enhances spin wave power emission [1].
- Fast magnetization reversal.
  - State-of-the-art agile MRAM [2]

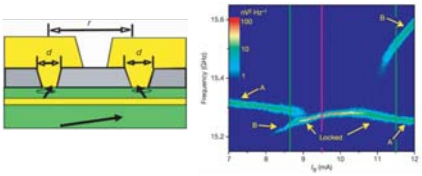


Fig.1: Phase-locking mode of a double point contact geometry by Kaka *et al.*

Aim of this work:

I. **Processing flow of Nano-point contacts**
   - Description of a Brillouin Light Scattering (BLS) device.

II. **Spin Waves**
   - BLS measurements.

III. **Electrical Characterization**
   - Vortex oscillations in sub-gigahertz domain.

IV. **Improvements in Processing**

Spin Waves – BLS**

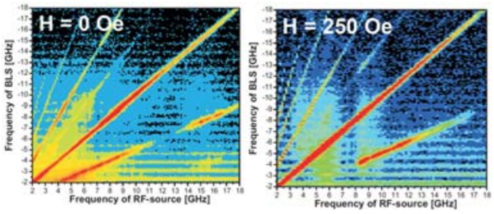


Fig2: Spectral intensity as function of 13dBm RF excitation frequencies for in-plane H = 0 Oe and H = 250 Oe magnetic fields.

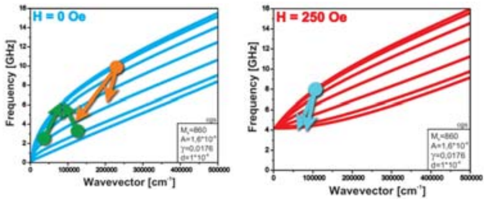


Fig.3: For O Oe, all magnon splitting processes are allowed. At 250 Oe, spin wave emission below 4 GHz is forbidden.

Vortex Oscillations [3]

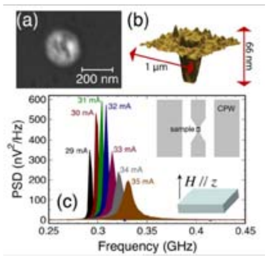


Fig.4: (a), (b) SEM and AFM images of point contacts. (c) Low Frequency PSD at H = 210 mT (out-of-plane) for different applied DC currents.

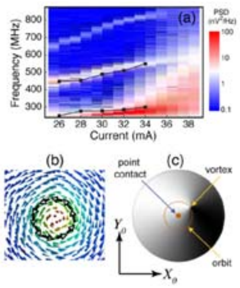
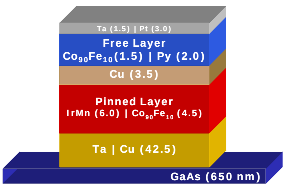


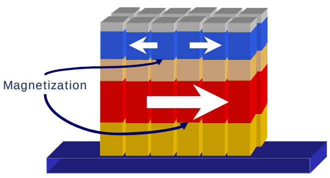
Fig.5: (a) Experimental PSD and micromagnetic simulations at H = 350 mT (solid squares).
(b), (c): Top view and in-plane component magnetization dynamics simulated for I = 30 mA.

Processing Flow – Brillouin Light Scattering device

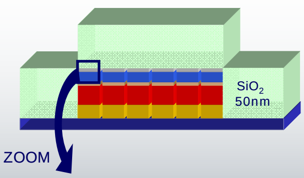
1. GMR stack is sputter deposited.



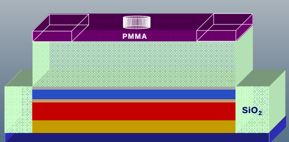
2. Bottom electrode defined by lift-off



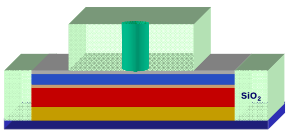
3. SiO_2 insulates the magnetic layers



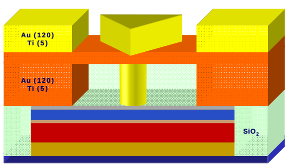
4. E-beam exposure defines 80 nm point contact and side contacts in PMMA resist.



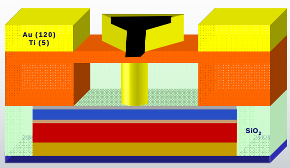
5. BHF dip etches a hole into the SiO_2 layer.
   Side contacts are opened
   Resist strip is done afterwards with acetone and IPA



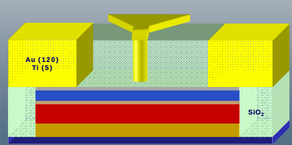
6. Unmasked sputter deposited Au/Ti film contacts the magnetic layers.
   Optical lithography defines CPW top electrodes.
   Second Au/Ti deposition is patterned by means of lift-off.



7. E-beam exposure on FOX12 resist (black) defines BLS tip



8. Ion milling transfers FOX12 pattern to CPW electrodes.
   Dry etching stopped when SiO_2 layer is reached.

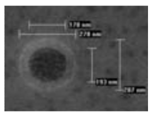


Improvements in Processing

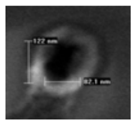
Point Contact shape

- smaller diameters → decrease of Oersted fields
- vertical and sharper sidewalls

Attempt: RIE as replacement for Wet Etch
- avoid underetching



Wet Etch: BHF



RIE Etch: C_4F_8

BLS top electrode

- Limited to low DC current due to top electrode shape and geometry
- CPP geometry confinement

Attempt: Thicker Au layer and new design

References

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