CPP GMR Devices: Fabrication and Properties

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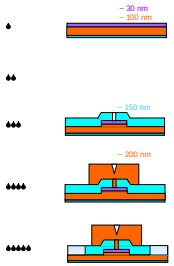
Motivation

CPP (Current Perpendicular to the Plane) GMR spin valves are candidates for the next generation read heads. We present the fabrication process of a CPP sensor with either antiferromagnetic (AFM) or hard magnet (HM) pinning.

Fabrication process

SV fabrication flow chart

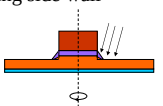


- Deposition of the bottom electrode+stack (blanket layer). Photolithography+ion milling to define shape (dog bone) for bottom electrode.
- Photolithography+ion milling to define shape for the stack (cylinder).
- Deposition of the insulator (SiO_2). Electron lithography+reactive ion etching to define the shape (circular hole) for the contact between stack and upper electrode.
- Deposition of the top electrode. Ion milling to define the top electrode.
- Photolithography+ion milling to open contacts for the bottom electrode.

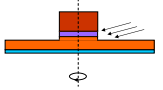
Ion milling calibration

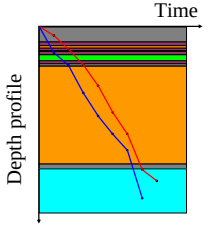
Two angle milling is used for preventing side wall redeposition

First step – steep angle milling

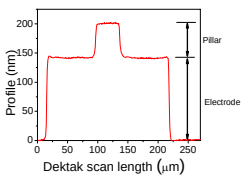


Second step – shallow angle milling



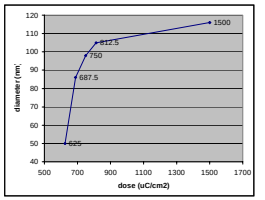


Evolution of the depth profile during the ion milling of a spin valve: blue line – only the steep milling angle was used, red line – both milling angles were used.



Profiles of the bottom electrode and the SV stack (pillar) after the first two steps of the fabrication (for each step, two angle milling was used).

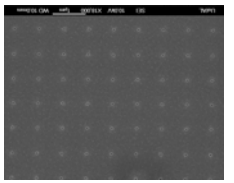
E-beam lithography calibration

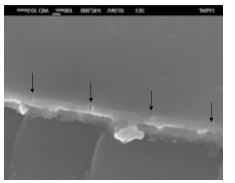


A circular region of 60 nm diameter was written in a positive e-beam resist by using various exposure times (doses). The diameter of the corresponding circular hole created in the e-beam resist after developing the resist is presented as a function of the exposure dose.

Reactive (ICP – Inductively Coupled Plasma) etching calibration

E-beam resist was spun onto a Si wafer coated with 150 nm thick CVD SiO_2. A matrix of holes (100 nm diam.) was created in the e-beam resist by e-beam exposure and developing, followed by a reactive ion etching step (70 sec). The e-beam resist was ached away by O_2 plasma. The wafer was then cleaved and an SEM picture of the cut side was taken.



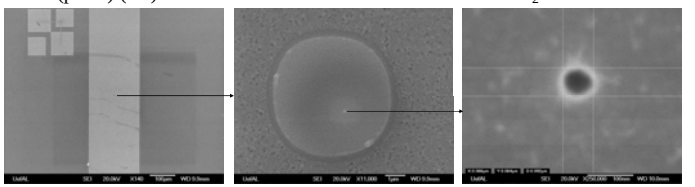


Images of contact holes on top of different SVs on the same wafer

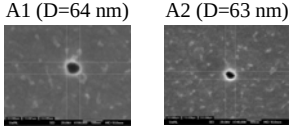
Bottom electrode + SV stack (pillar) (B5)

SV stack (pillar)

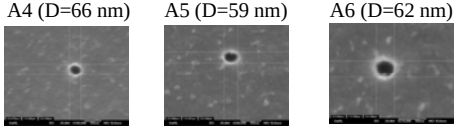
Contact hole through the SiO_2



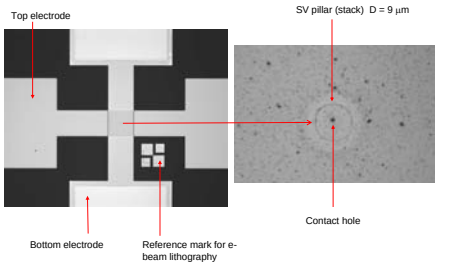
A1 (D=64 nm) A2 (D=63 nm) A3 (D=65 nm)

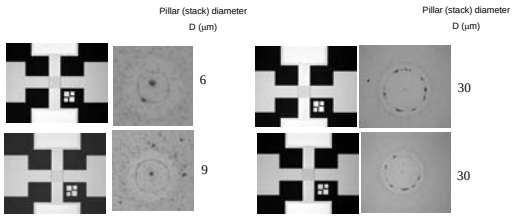


A4 (D=66 nm) A5 (D=59 nm) A6 (D=62 nm)



Optical images of various SV sensors at the end of the fabrication process





Summary

The steps of the fabrication process of a CPP spin valve were described. This process will be used for investigating the CPP GMR in relation to the contact hole diameter.

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