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Publication date: 2016

Document Version
Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA):

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Multi-electrode probe optimization for characterization of magnetic tunnel junction stacks

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One of the most important metrologies extensively used world-wide for evaluation of Magnetic Tunnel junction (MTJ) stacks is the current-in-plane tunneling (CIPT) technique. The CIPT method has been of fundamental importance in the development of MRAM technology in the past decade. Until now, the design of multi-electrode probes and choice of sub-probes have been based on a best guess practice. In this study, we perform a numerical optimization of the geometrical design of multi-electrode probes as well as optimal choice of subprobes. A drastic improvement in the measurement precision for the resistance-area product and the TMR is achieved.

![Micro 12 Point Probe (M12PP)](image)

**Measurement Precision prediction**

By modeling the main noise sources of the CIPT measurement the precision, intended as the relative standard deviation (STD) on RA and MR, can be predicted with a software tool. 4 different MTJ stacks and different probe geometries were tested.

**M4P Subprobe sequence Optimization**

Currently for every MTJ sample the same M4P subprobe sequence is used (STD sequence), with a electrode pitch ranging from 1.5 to 8.25 μm for a total of 8 M4P subprobes.

**Optimization:** The optimization software is able to test thousands of subprobe sequences to identify the sequences that maximize the precision on RA and/or MR, given a specific MTJ sample.

**Electrode position Optimization**

Currently for every MTJ sample the same M4P subprobe sequence is used for a fixed M12PP geometry.

**Optimization:** combining the optimization of the subprobe sequence and the optimization of the electrode positions an improvement up to 3 times can be achieved on the measurement precision of TMR and RA (for $\lambda = 0.68 \, \mu m$).

**Bibliography**