High resolution mapping of non-patterned MRAM film stacks

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The need for suitable metrology is increasing as the industry moves towards actual volume production of MRAM and starts focusing on sample homogeneity and other performance related factors [1]. To identify the usable area of a wafer is of fundamental importance in a production environment. The defining parameters of magnetic tunnel junctions (MTJ) are the resistance-area product (RA) and magnetoresistance (MR). For the past decade, the Current In-Plane Tunneling (CIPT) technique [2] has been the standard method to characterize these parameters. Due to CIPT measurement time (~2 min./pt.) the technique is generally not used for full wafer analysis with high spatial resolution.

We present CIPT line scans and high density area mapping (see fig. 1) revealing variations of RA and MR far exceeding acceptable process variations (+/-10 %). We demonstrate that the information from line scans alone is insufficient to define an optimal edge exclusion zone, as this would lead to significant loss of otherwise usable wafer area. In order to define the optimal edge exclusion zone, high density mapping is needed to map tool process variability.

We find that variations in RA is the most critical process parameter as compared to the variations of MR (see fig. 2), and propose the necessary information can be obtained purely by measuring RA. This reduces the measurement time by at least a factor of 3. Further reduction of the measurement time is obtained by optimization of the number of samplings per measurement point. MR control measurements may still be required, but since the MR variability is generally insignificant as compared to the variability in RA, high resolution MR mapping is not necessary.

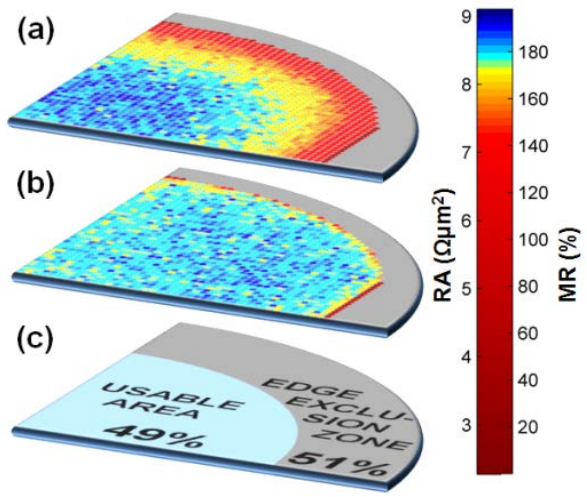

Fig. 1. High density mapping of RA (a) and MR (b) obtained with 2 mm step size on a quarter of a 200 mm wafer. (c) The usable wafer area vs. edge exclusion zone based on an acceptance limit of +/-10 % with respect to the mean value at the center of the wafer.

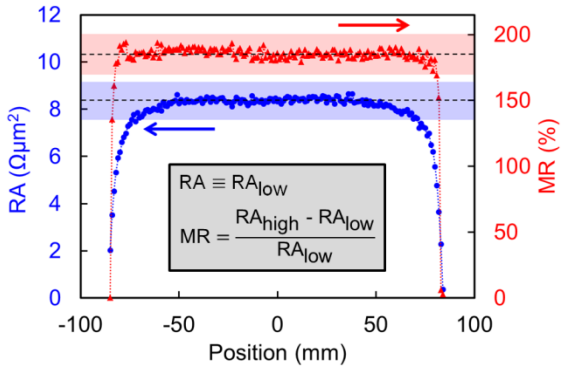

Fig. 2. Line scan measuring RA and MR with a step size of 1 mm across a 200 mm wafer. The colored areas behind the plots mark a +/-10 % band with respect to the mean values pointed out by the dashed lines. The insert shows the definition of RA together with the formula for MR.

Keywords: Magnetic tunnel junction, four-point probe resistance measurements, magnetoresistance, MRAM.

References:

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[2] D. C. Worledge and P. L. Trouilloud, Appl. Phys. Lett. 83, 84-86 (2003).