CAPRES A/S
COPENHAGEN APPLIED RESEARCH

SPM-CIPTech Sample Preparation Guidelines

The following guidelines are intended to help in the preparation of Magnetic Tunnel Junction (MTJ) film stacks to be measured with the SPM-CIPTech.

1) Characteristic length λ: The sheet resistance of the top and bottom layers, R_T and R_B, respectively, should optimally and ideally be chosen in order to meet the following criteria:

$$\lambda = \sqrt{\frac{RA}{R_T + R_B}}, 1.5\ \mu m < \lambda < 35\ \mu m$$

where RA is the resistance-area product of the tunnel junction stack.

For MTJs with low RA-values (<3 Ωμm^2), it may not be feasible to achieve λ > 1.5 μm. However, measurements on several optimized low-RA samples have shown that reliable results are obtained for λ as low as 0.7 μm.

Example: A sample with R_T = 1.3 Ω/□, R_B = 0.24 Ω/□, RA = 0.75 Ωμm^2 yields λ = 0.7 μm, but still provided a standard deviation of 1.5% (see "3) Signal level" below).

2) Cap layer: Please cap the MTJ stack with 70 Å of Ru. The cap layer should ideally be deposited prior to anneal. If deposited after anneal, the surface of the stack must first be cleaned by ion milling to remove surface oxidation.

3) Signal level: Ensure that the top layer does not short out the signal from the rest of the tunnel junction. The following criteria should be met as a bare minimum for the top and bottom electrode sheet resistance (R_T and R_B, respectively):

$$R_T / R_B > 0.1$$

In several cases, R_T/R_B is critical:

For low-RA samples, $R_T/R_B \approx 3$ typically provides the best results.

For high-MR (MR > 50%, e.g. MgO) samples, it has been found that $R_T/R_B > 10$ typically provides the best results.

However, in all cases the optimum R_T/R_B-ratio will depend on the actual samples, and can only be found by empirical testing.

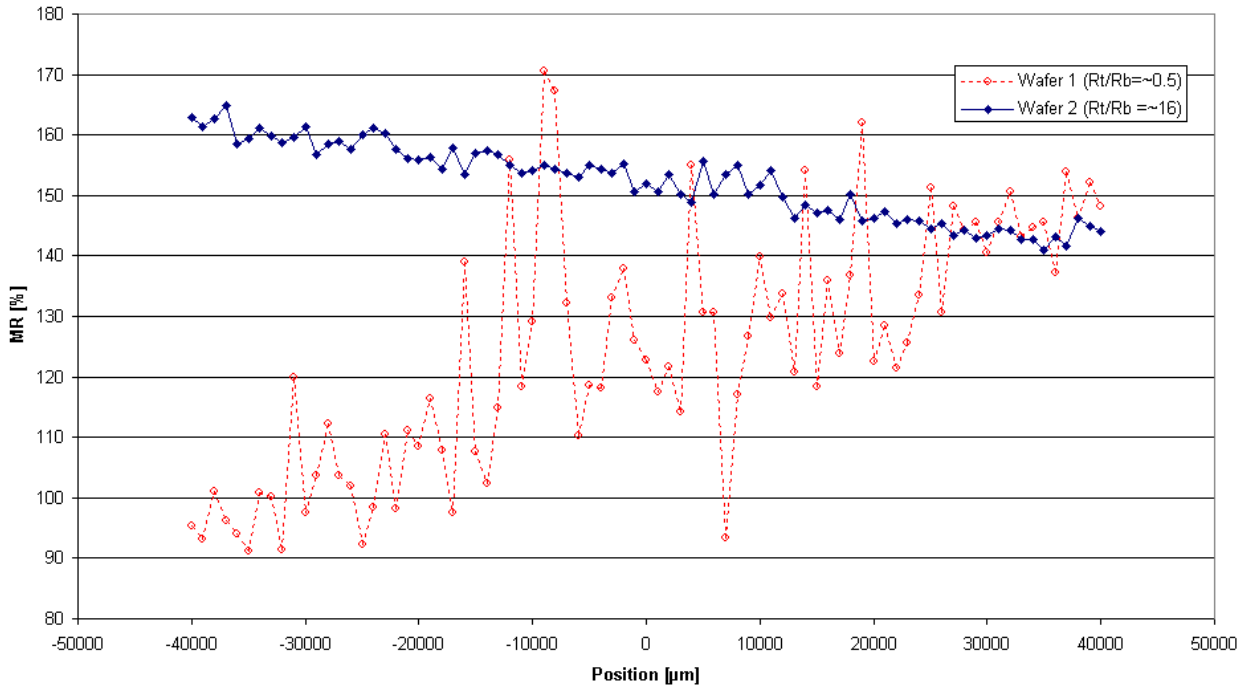
Note, that the "intrinsic" R_T and R_B values for the MTJ-stack may not necessarily provide an optimum situation for the CIPT-model. It may consequently be necessary to adjust (lower) R_T and/or R_B by adding additional layers of e.g. CuN or Cu below and/or above the stack.

Ensure the total resistance of the stack is larger than 0.05 Ω/Ω, i.e.:

$$\frac{R_T \cdot R_B}{R_T + R_B} > 0.05\ \Omega / sq$$

4) For more information please contact info@capres.com. A detailed description of the CIPT method can be found in the paper "Magnetoresistance measurement of unpatterned magnetic tunnel junction wafers by Current In-Plane Tunneling", D.Worledge and P. L. Trouilloud, Applied Physics Letters Vol 83 1 pp 84-86 July 7th 2003.

Appendix 1 The importance of adjusting the R_t/R_b-ratio for high-MR samples



MR vs. position for 2 wedge-wafers; one (Wafer 1) with unsuitable R_t/R_b-ratio (equal to approx. 0.5), and the other (Wafer 2) with improved R_t/R_b-ratio (equal to approx. 16). Both wafers had almost similar MTJ-stacks, and similar measurements conditions were used in both cases.