Buffer influence on magnetic dead layer, critical current and thermal stability in magnetic tunnel junctions with perpendicular magnetic anisotropy

M. Frankowski1, A. Żywczyk2, M. Czapkiewicz1, S. Ziętek1, J. Kanak1, M. Banasiak1, W. Powroźnik1, W. Skowronski1, J. Chęciński1,3, J. Wrona1, H. Głowiński4, J. Dubowik5, J-Ph. Ansermet1 and T. Stobiecki1

1 Department of Electronics, AGH University of Science and Technology, Kraków, Poland
2 Academic Center of Materials and Nanotechnology, AGH University of Science and Technology, Kraków, Poland
3 Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Kraków, Poland
4 Institute of Molecular Physics, Polish Academy of Sciences, Poznan, Poland
5 Institute of Condensed Matter Physics, Ecole Polytechnique Fédérale de Lausanne, CH-1015 Lausanne, Switzerland

Motivation
Magnetic Tunnel Junctions (MTJs) with Perpendicular Magnetic Anisotropy (PMA) have recently brought a significant attention in view of application as high-density non-volatile magnetic random access memory due to their possible low critical current density, good thermal stability and downscalable junction size.

Aims
In order to optimize critical current and thermal stability of MTJs we investigate Ta/Ru-based buffer influence on the microstructure and magnetic properties. We examine current-induced switching in nanopillars and perform additional measurements of damping in order to explain obtained results.

Step 1: Samples preparation
Fe80Co20-based structures using a Singulus Tamaris cluster tool system

Step 2: Microstructure
XRD texture measurements

Step 3: Magnetic properties
VSM and p-MOKE measurements

Step 4: Nanostructurization and CIMS
VSM measurements of anisotropy fields
Buffer (a) free layer Hc=1010 Oe, reference layer Hc=5620 Oe
Buffer (c) free layer Hc=920 Oe, reference layer Hc=5330 Oe

Step 5: Damping measurements
Damping calculated from VNA-FMR

Summary and conclusions
• Buffer (a) Ta 5 / Ru 10 / Ta 3 : the thickest dead layer, the weakest texture, the smallest roughness and MOKE images with one large domain
• Buffer (b) Ta 5 / Ru 20 / Ru 5 : the thinnest magnetically dead layer, the strongest texture, the biggest roughness and irregular domain images
• Buffer (b) Ta 5 / Ru 10 / Ta 10 : intermediate properties between the other two
• Buffer (a) has larger anisotropy fields than buffer (c)
• Critical current - buffer (a) slightly better than buffer (c)
• Thermal stability - two-fold difference in favour of buffer (a)
• Difference in damping: 44% greater for buffer (c)
• We conclude that the difference in damping factors compensates for the difference in the switching barrier heights. As a result, by adjusting buffer characteristics one can obtain a significant increase in thermal stability factors while keeping the critical current values at a similar level.

Acknowledgements:
The study was co-financed through the Swiss Contribution, project NANOSPIN-PSPB-045/2010, AGH dean’s grant, and Ministry of Science and Higher Education, Diamond Grant, project DI01001541, statutory activity of AGH University of Science and Technology, Faculty of Informatics, Electronics and Telecommunications 11.11.230.016 and Polish National Science Centre Grant DEC-2012/05/E/ST7/00240.