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Time-to-breakdown characteristics of magnetic tunnel junctions

Young Man Chang[1], Injun Hwang[1], Byung Ki Cho[1], Young Keun Kim[2], Wanjun Park[3], Taewan Kim*[3]

[1] Kwangju Institute of Science and Technology, Gwangju 500-712, Korea
[2] Division of Materials Science and Engineering, Korea University, Seoul 136-701, Korea
[3] Materials and Devices Laboratory, Samsung Advanced Institute of Technology, Gyeonggi-Do 449-711, Korea

*Corresponding author: e-mail: twkim2@sait.samsung.co.kr, Phone: +82 31 280 9394, Fax: +82 31 280 9308

Reliability of ultra-thin insulating layer cotaining tunnel junctions is of great importance for MRAM development. The tunnel barrier of magnetic tunnel junction (MTJ) has a tendency to dielectric breakdown. Therefore, the time dependence dielectric breakdown (TDDB) measurement can be used to evaluate the reliability of ultra-thin insulating layer. To investigate the reliability of the MTJs on the thickness uniformity of insulating tunnel barrier, we prepared two MTJs with the different uniformity of barrier thickness. Namely, the one has uniform insulating barrier thickness, the other has non-uniform insulating barrier thickness as compared to different thing. In case of the former, the detailed layer sequence of the MTJ stack is SiO_2 / TiN / CoZrNb / IrMn / CoFe / Ru / CoFe/ AlO_x / CoFe / NiFe / Ru, the latter is SiO_2 / Ta / Ru / IrMn / CoFe / Ru / CoFe/ AlO_x / CoFe / NiFe / Ru, that is, the normal synthetic anti-ferromagnetic structure. As to depositing amorphous layer CoZrNb under the pinning layer IrMn, we achieved MTJ with uniform barrier thickness. First of all, we performed the breakdown-voltage measurement of two junctions and obtained the result having a similar breakdown-voltage about 1.3V at two all junctions. And then, the TDDB measurements of two junctions are carried out under constant voltage stress of 0.95V, 1V, 1.05V, 1.1V etc. The Weibull fit of our data shows clearly that t_{BD} scales with the thickness uniformity of tunnel barrier. And also, Assuming a linear dependence of $\log(t_{BD})$ on stress voltages, we meet with result about the different lifetime of the two MTJs with uniform barrier thickness or non-uniform barrier thickness .

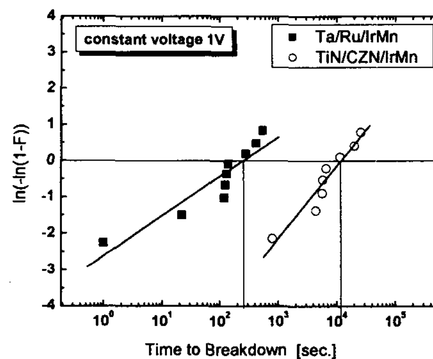

Fig 1. Different reliability with the thickness uniformity of tunnel barrier