Multilayer Structure with Increased Operation Field Margin for MRAM

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Abstract
- Magnetoresistance random access memory (MRAM) will be a non-volatile, power-saving, high-speed memory in future.
- In MRAM, thermal agitation combined with either digit or word disturb limits the operation field margin, causes unexpected switching, and affects the stability of the memory states.
- New structure is necessary to be developed to increase the operation field margin for effective reading and writing in MRAM.
- The switching astroid of multilayer structure has an elongation in hard direction, which can broaden the operation field margin.

From Goto’s model to tri-layer model

Goto’s model (curve a) and tri-layer model (curve b) have an astroid elongation in hard direction. This elongation will possibly give wider operation field margin.
- The configuration is \((h_1, h_2, h_3) = (1, 1, 1)\) for infinite elongation.

Conclusion
- The interlayer can be introduced as the cosine exchange coupling between the soft and hard layers.
- The interlayer can be synthetic antiferomagnet instead of antiferromagnet.
- The astroid has an elongation in \(h_y\) direction, the operation field margin is greatly enhanced, and effective writing and reading can be possibly guaranteed.

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Word and digit disturbances in MRAM array

Word and digit disturbances both affect elements during the normal switching.
- The disturbances combined with the thermal agitations could cause an unwanted switch.

Energy barrier (easy direction)
- Energy barrier becomes lower with the increasing of applied field.
- Thermal agitation combined with field disturbances in easy direction may cause unexpected switch.
- If the critical energy for the above parameters with \(N_w=10^6\), critical field \(h = 0.93\).

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Operation margin
- Margin is evaluated by Néel-Arrhenius formula with writing disturbances \(N_w=10^6\).
- Green filled area is the obtained operation margin for tri-layer structure.
- Operation margin is greatly enlarged compared to the ordinary uniaxial anisotropy structure.