Optimization of Magnetic Parameters for Toggle Mode MRAM

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This project was funded by grant NSF MRSEC - DMR 0213985.

Abstract

- Magnetoresistance random access memory (MRAM) will be a non-volatile, power-saving, high-speed memory in future.
- A novel scheme of sequential pulse-driven MRAM has been systematically analyzed in the aspects of operation field margin, thermal stability, and magnetic parameter optimization.
- This analysis will help the research and development of the next generation of MRAM.

Model structure

Word line $I_w$

Synthetic antiferromagnet (SAF)

free layer structure

Tunnel junction

Pinned layer structure

$H_x$: word field, applied at 45° to easy axis.

$H_z$: digit field, applied at -45° to easy axis.

Different switching traces

Critical curve of SAF ($h_y = 2$)

Critical curve includes two switching astroids and a saturation contour.

If the applied field is outside the contour, $M_1$ and $M_2$ are aligned to parallel and the memory is lost.

Field sequence trace (red vectors) outside the astroid can lead to a switch.

Energy mapping with half field applied

Operating Field Margin

No switch

Switch

Conclusion

- Switching critical curves for SAF were obtained.
- Methods for determining the operating field margin and magnetic parameter optimization for toggle-MRAM are setup.
- Control of especially low exchange coupling strength in the SAF in addition to the increase of the operating field has been found to be essential for the development of toggle-MRAM in near future.

Reference:

1 Savtchenko et al. US Patent No. US 6,545,906 B1 Apr. 8, 2003

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