



# Anisotropy Engineering, Stacks and Process for All Metal Spintronic Devices (20100207, Dr. Jian-Ping Wang)

## STT-MRAM Bit Design with Combined In-Plane and Perpendicular Magnetic Polarizers

A newly designed magnetic tunnel junction (MTJ) device features a fixed magnetic layer with magnetic anisotropy out of the film plane (e.g., a generally perpendicular magnetic anisotropy) with a tunnel barrier layer on one side of the fixed magnetic layer. A stack of bilayers with magnetic anisotropy outside the film plane is adjacent to a second side of the fixed magnetic layer. The stack of bilayers and the fixed magnetic layer are exchange coupled to fix the fixed magnetic layer's anisotropy. The key components of this technology are the design and development of the CoFeB/(Co/Pd)<sub>n</sub> multilayer, which acts as a perpendicular polarizer, and the design of the material stack that successfully combines this polarizer with MgO tunnel barriers. Either the bottom pinned layer (BPL) or the top pinned layer (TPL) layer can act as the perpendicular polarizer. The magnetic materials and layered structures and processes of this technology engineer the magnetic anisotropy (direction) of magnetic layers in magnetic tunnel junctions and giant magnetoresistive devices and can enable perpendicular magnetic polarizers for spintronic devices (MTJ, GMR, etc.).

## Design Reduces MRAM Writing Energy and Switching Time

Traditional, all-metal based spintronic devices (MTJ, GMR, etc.) use in-plane anisotropy, in which magnetization of both the free layer and fixed layer is in the plane. This design requires significant writing energy and time to switch the magnetization from one direction to another for MRAM applications, generates less power for a spin oscillator, and requests the hard bias for magnetic sensors. The new approach, which engineers the magnetization direction of the fixed layer (pinned layer) of these devices to a favored one (e.g. perpendicular direction), tremendously reduces the writing energy and switching time of STT-RAM. Furthermore, previously reported stacks cannot resist high-temperature annealing (necessary for MgO barrier magnetic tunnel junctions) and therefore have a much lower magnetoresistive (MR) ratio. This new stack and process prepares [Co/Pd]<sub>n</sub> perpendicular materials and its integration with CoFeB that can resist high annealing temperatures, increasing the MR ratio by 60%.

### BENEFITS AND FEATURES:

### Technology ID

20100207

### Category

Engineering & Physical

Sciences/Semiconductor

Software & IT/Communications &

Networking

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- CoFeB/(Co/Pd)n multilayer as a perpendicular polarizer
- Engineers the magnetic anisotropy of magnetic layers in MJTs and giant magnetoresistive devices
- Enables perpendicular magnetic polarizers for spintronic devices (MTJ, GMR, etc.)
- Either the bottom pinned layer (BPL) or the top pinned layer (TPL) layer can act as the perpendicular polarizer
- Reduced writing energy and switching time of STT-RAM
- MR ratio improved by 60%
- Resists high annealing temperatures
- Additional features as needed

#### APPLICATIONS:

- MRAM
- Magnetic Logic
- Spin Oscillator
- Application

**Phase of Development** - Conceptual

#### Interested in Licensing?

The University relies on industry partners to scale up technologies to large enough production capacity for commercial purposes. The license is available for this technology and would be for the sale, manufacture or use of products claimed by the issued patents. Please contact us to share your business needs and technical interest in this technology and if you are interested in licensing the technology for further research and development.

#### Researchers

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#### Publications

[\*Reduction of switching current density in perpendicular magnetic tunnel junctions by tuning the anisotropy of the CoFeB free layer\*](#)

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