Spintronic Nanodevices for Neuromorphic Sensing Chips

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Abstract:

Recent developments in spintronics materials and physics are promising to develop a new type of magnetic sensors which can be embedded into the silicon chips. These neuromorphic sensing chips will be designed to capture the biomagnetic signals from active biological tissue exploited as brain-machine interface. They lead to machines that are able to sense and interact with the world in humanlike ways and able to accelerate years of fitful advance in artificial intelligence. To detect the weak biomagnetic signals, this work aims to develop a CMOS-compatible spintronic sensor based on the magnetoresistive (MR) effect. As an alternative to bulky superconducting quantum interference device (SQUID) systems, the miniaturised spintronic devices can be integrated with standard CMOS technologies makes it possible to detect weak biomagnetic signals with micron-sized, non-cooled and low-cost. Fig. 1 shows the finite element method (FEM)-based simulation results of a Tunnelling-Magnetoresistive (TMR) sensor with an optimal structure in COMSOL Multiphysics. The finest geometry and material are demonstrated and compared with the state-of-the-art. The proposed TMR sensor achieves a linear response with a high TMR ratio of 172% and sensitivity of 223 μV/Oe. The results are promising for utilizing the TMR sensors in future miniaturized brain-machine interface, such as Magnetoencephalography (MEG) systems for neuromorphic sensing.

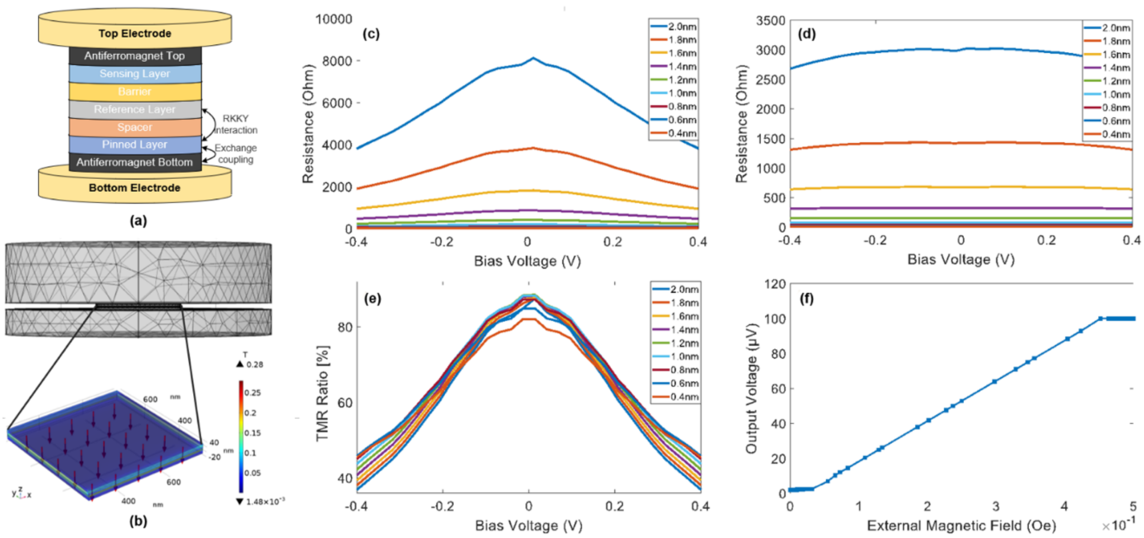

Fig.1 Schematic of the TMR stack layout used for FEM simulations.

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