Tunneling Anisotropic Magnetoresistance above Room Temperature through Iron Quantum Wells

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The quantum well (QW) devices have found a wide use in semiconductor technologies. However, metallic QW devices are still at fundamental research interest. In a recent Letter [1], we demonstrated the control of quantized levels formed in ultrathin Fe QWs in magnetic tunnel junctions (MTJs) devices. We found that the magnetization angle has a similar role as transistor's gate voltage, where both can control the energy positions of the quantization levels.

We found a large tunneling anisotropic magnetoresistance (TAMR) effect in Fe QWs formed in a (001)-oriented Cr/ultrathin Fe/$MgAl_2O_4$/top electrode MTJ epitaxial stack, where the confinement is made by the Δ_1 band-symmetry mismatch between Cr and Fe [Fig. 1(a)]. This QW-TAMR is relatively large reaching 5% at 5 K [Fig. 1(b,c)], and remains sizable even above room temperature (1% at 380 K). Our experiments and calculations revealed that the QW levels are significantly shifted (up to 50-meV) by magnetization rotation [Fig. 1(c)], resulting in this new QW-TAMR effect. The QW-TAMR effect resembles a spintronic analogue to the fine-structure of the atomic spectral lines, due to spin-orbit coupling (SOC). We will present further evidences on the band symmetry character of the tunneling conduction in our QW MTJs, by choosing different counter electrodes.

Therefore, we argue that "magnetic gating" can add to the functionalities of metallic QW devices, compared to the non-magnetic semiconductor counterparts.

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Ref.:

[1] M. Al-Mahdawi *et al.*, "Quantum-well tunneling anisotropic magnetoresistance above room temperature," Phys. Rev. B **103**, L180408 (2021). DOI: 10.1103/PhysRevB.103.L180408

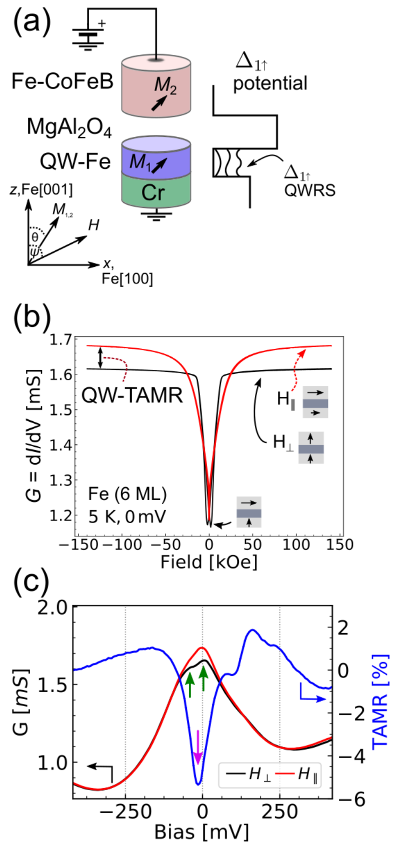

Fig. 1: QW-TAMR effect. (a) MTJ schematic, (b) Conductance anisotropy in field direction, (c) QW-TAMR spectrum.