Simulation study of ballistic spin-MOSFET devices with ferromagnetic channels based on Heusler and oxide compounds

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Newly emerged materials from the family of Heuslers and complex oxides exhibit finite bandgaps and ferromagnetic behavior with Curie temperatures much higher than even room temperature. Using the semiclassical top-of-the-barrier FET model, we explore the operation of a spin-MOSFET that utilizes such ferromagnetic semiconductors as channel materials, in addition to ferromagnetic source/drain contacts.

Such a device could retain the spin polarization of injected electrons in the channel, the loss of which limits the operation of traditional spin transistors with non-ferromagnetic channels. Although the investigated compounds are Mn\textsubscript{2}CoAl, CrVZrAl, CoVZrAl, and NiFe\textsubscript{2}O\textsubscript{4}, we expect that the insight we provide is relevant to other classes of such materials as well. \textit{Ref. P. Graziosi and N. Neophytou, J. Appl. Phys. 123, 084503 (2018).}

\textbf{Toshiba’s spin MOSFET}

Sufficient operation only at low T
Possible loss of Spin Polarization in the Si channel

\textbf{Our Proposal spin-MOSFET with ferromagnetic channel}

Ferromagnetic semiconductor channel to retain the Spin Polarization of the injected current

\textbf{The Model}

Ballistic MOSFET with spin dependent contact resistances

\textbf{Generic band structure}

Parameters are chosen to be close to the typical DFT band structures of ferromagnetic semiconducting Heusler (Mn\textsubscript{2}CoAl, CrVZrAl, CoVZrAl,...) m\textsubscript{eff} = m\textsubscript{0} for the early evaluations, then from DFT calculations

\textbf{Confinement effect}

dotted lines: non parabolicity effects

\textbf{Real materials – bandstructures in the insets}

A new spin MOSFET concept has been explored
Actual ferromagnetic Heuslers require thin layer confinement
Promising candidate for spin-MOFETS with RT operation

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