performance, indicating that this process is effective for constructing optimized pore architectures for energy storage. [5]

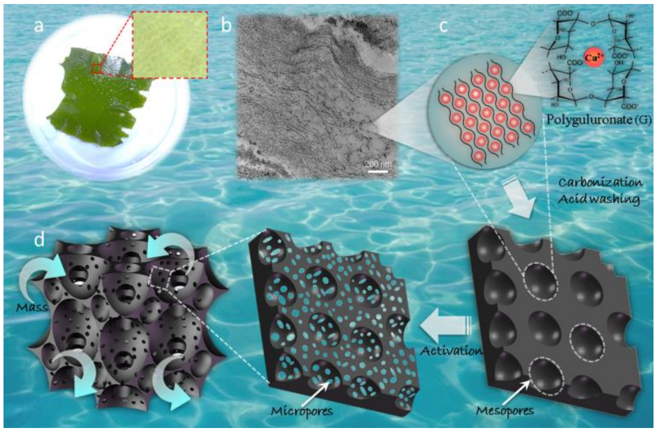

Figure 1. The “egg-box” model of calcium alginate in brown seaweed and the process for nanoporous carbons. (a) Brown seaweed Undaria pinnatifida. (b) Transmission electron microscopy (TEM) image of cross section of the cell walls. (c) Illustration of cation binding in alginate to form the “egg-box” structure. (d) Schematic of an alginate-based SME process to orderly assemble mesopores and micropores on seaweed-derived carbon frameworks.

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## A01: Novel Spintronic Devices for Embedded Spin-based Memories and Non-volatile Computing

T. Windbacher, A. Makarov, V. Sverdlov, and S. Selberherr

*Institute for Microelectronics, TU Wien, Vienna, Austria*
*Email:{windbacher|makarov|sverdlov|selberherr}@iue.tuwien.ac.at, web site: http://www.iue.tuwien.ac.at*

For many decades CMOS scaling was the key to stay competitive in the semiconductor industry. It allowed to pack more devices onto the same die space for each new technology generation and by that to build consecutively more powerful electronics [1]. Continuing scaling has forced engineers to resolve many technological challenges to maintain the control over the channel in CMOS transistors. It prompted the continuous introduction of innovations like local and global strain techniques, high-k/metal gates, and Tri-gate FETs. At present, the static power dissipation and the interconnection delay increase for each new technology node have become the most pressing problems [2]. A very powerful but simple solution to the static power dissipation problem is to shut down unused circuit parts and only reactivate them when they are needed. But when a circuit is turned off, the information it stores vanishes because of leakage. Therefore, every time the circuit is shut down all the local information has to be saved externally and must be copied back again when the circuit is reactivated. This is undesirable as it takes time due to the interconnection delay and costs extra dissipated power. To avoid this, one must add non-volatile elements close to the circuits, which requires a complete reevaluation and redesign of all basic CMOS building blocks.

Spin-based devices are very promising due to their non-volatility, high endurance, and CMOS compatibility [3]. By arranging the elements of the basic magnetic tunnel junction (MTJ) structure differently, one can improve the performance and add functionalities. We proposed a fast-switching MTJ-based memory cell [4] with a composite free layer and a non-volatile flip flop [5] based on two MTJs with a common active layer. However, the still rather high current density required to switch the magnetization in these structures leads to high switching energies and may even damage the tunnel oxide. We discuss a possibility to reduce the switching energy and to decouple the reading and the writing path to eliminate the tunnel oxide degradation by exploiting the spin Hall effect [6] in these structures. We propose a cross point architecture memory cell (Fig. 1) and a non-volatile magnetic flip flop (Fig. 2) that facilitate the use of the spin Hall effect for a simultaneous reduction in switching time and switching energy, while maintaining a high integration density. The proposed flip flop can be incorporated into a functionally complete and fully non-volatile spintronic computing environment [7].

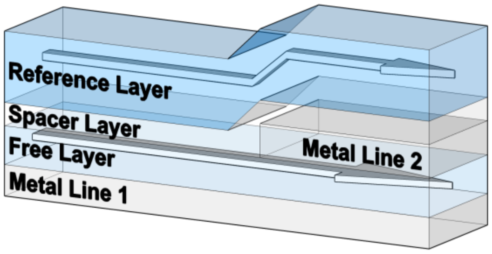

Fig1. Schematic illustration of a memory cell with two orthogonal spin Hall metal lines for switching.

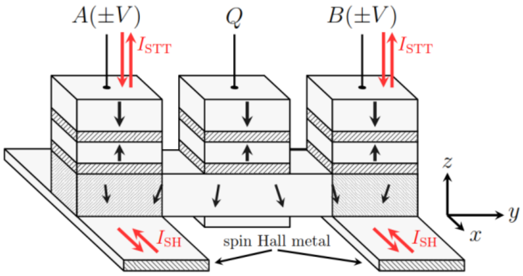

Fig2. The non-volatile magnetic flip flop exhibits three antiferromagnetically coupled polarizer stacks (*A*, *B*, and *Q*), which are connected via a common free layer. The common free layer resides on two spin Hall metal lines.

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## A02: Improved magnetoelectric characteristics in Mn doped multiferroic ceramics

Pratap Kollu

*Cavendish Laboratory: Department of Physics, University of Cambridge, UK*

Multiferroic single phase BiFeO3 (BFO) and Mn doped Bi0.95Mn0.05FeO3 (BMFO), and di-phase BiFeO3-Ni0.5Zn0.5Fe2O4 (BFO-NZFO) and Mn doped Bi0.95Mn0.05FeO3-Ni0.5Zn0.5Fe2O4 (BMFO-NZFO) composites have been prepared by combining sol-gel autocombustion and solid state methods. X-ray diffraction studies on these samples reveal rhombohedrally distorted single phase R3c perovskite structures for the BFO and BMFO samples while the di-phase composites exhibit both the individual spinel (for the NZFO) and perovskite phases. Scanning electron micrographs of the samples show uniformly dispersed fine grained microstructures with indications of decreased grain size for the Mn doped samples. Polarization-electric field hysteresis (P-E) loops on the samples exhibit spontaneous ferroelectric polarizations with specific enhancements in the remnant polarization by the Mn doping either in