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Ultra low-power straintronics with multiferroic nanomagnets: magnetization dynamics, universal logic gates and associated energy dissipation MOHAMMAD SALEHI-FASHAMI, JAYASIMHA ATULASIMHA, SUPRIYO BANDYOPADHYAY, Virginia Commonwealth University — Stress induced magnetization dynamics of dipole coupled multiferroic nanomagnet arrays is modeled by solving the Landau-Lifshitz-Gilbert (LLG) equation. We show that in such multiferroic nanomagnets, consisting of magnetostrictive layers elastically coupled to piezoelectric layers, the single domain magnetization can be rotated by a large angle ($\sim 90^\circ$) in ~ 1 ns if a tiny voltage of a few tens of millivolts is applied across the piezoelectric layer [Nanotechnology, 22, 155201, 2011, Appl. Phys. Lett. 99, 063108, 2011]. Arrays of such multiferroic nanomagnets can be laid out in specific geometric patterns to implement combinational and sequential logic circuits by exploiting inter-magnet dipole coupling and Bennett clocked with specific stress cycles to propagate logic bits and implement dynamic logic. In this work, we theoretically demonstrate logic propagation in and fan-out characteristics of a universal NAND gate and discuss energy dissipation in the magnet and in the external clock. We show that this energy dissipation can be 3 orders of magnitude more energy-efficient than current CMOS technology for a reasonable clock speed of 1 GHz. This work is supported by the NSF under grant ECCS-1124714.

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