

# The Piezoelectronic Family of Devices, from RF Switches to Fast Low Power Transistors

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A transduction based family of devices based on a piezoelectrically driven metal insulator transition is described [1]. An input voltage pulse activates a piezoelectric element (PE) which transduces input voltage into an electro-acoustic pulse that in turn drives an insulator to metal transition (IMT) in a piezoresistive element (PR); the transition effectively transduces the electro-acoustic pulse to voltage. Using the known properties of bulk materials, we predict using modeling that the device achieves multi-GHz clock speeds with voltages as low as 0.1 V and a large On/Off switching ratio ( $\approx 10^4$ ) for digital logic. The switch is compatible with CMOS-style logic. At larger scale the PET is predicted to function effectively as a large-area low voltage device for use in sensor applications and as a RF switch for applications in communications. Given PR materials with a hysteretic insulator metal transition, the memory component of the technology is realized.

The performance of our device is enabled by the properties of two materials, a relaxor piezoelectric for the PE and a rare earth chalcogenide piezoresistor for the PR - provided the materials exhibit bulk properties at the nanoscale. Thus it is critical to investigate materials scaling using a combined theoretical/experimental approach. The development of thin film piezoresistive and piezoelectric materials and patterned structures, and associated characterization tools is presented, along with the theoretical models that yield insight into their behavior [2-4]. Integration of these novel materials into 3 evolutionary generations of PET devices, and device characterization, is given [5] to show that a proof of concept has been achieved.

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2. "Giant Piezoresistive On/Off Ratios in Rare-Earth Chalcogenide Thin Films Enabling Nanomechanical Switching", G.J. Martyna et al, *Nano Lett.* **13**, 4650 (2013).
3. "Anisotropic strain in SmSe and SmTe: implications for electronic transport G.J. Martyna et al, *Phys. Rev. B.* **90**, 245124 (2014).
4. "Lateral scaling of PMN-PT thin films for piezoelectric logic", G.J. Martyna et al *J. Appl. Phys.* **115**, 234106 (2014).
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