Antiferromagnetic spintronics

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Louis Néel pointed out in his Nobel lecture that while interesting from theoretical viewpoint, antiferromagnets did not seem to have any applications. Indeed, the alternating directions of magnetic moments on individual atoms and the resulting zero net magnetization make antiferromagnets hard to control by tools common in ferromagnets. This has hindered both the research and utility of these abundant magnetic materials. Recent studies have shown, however, that relativistic quantum mechanics can provide staggered current induced fields whose sign alternates within the magnetic unit cell of the antiferromagnet and can be used to efficiently reorient the Néel vector. Combined electrical writing and electrical readout have been experimentally demonstrated in thin-film antiferromagnets CuMnAs or Mn_2Au and a proof-of-concept USB device has been realized showcasing binary and multi-level characteristics of memory cells fabricated in these antiferromagnets. The absence of dipolar fields is favorable for high density integration and makes the memory robust against external magnetic field perturbations. The multi-level switching allows to integrate memory with logic or neuromorphic functionalities within the bit cell. Another unique merit of antiferromagnets is the ultra-fast, THz spin dynamics which has allowed to demonstrate switching by electrical pulses whose length has been scaled down to a picosecond. Despite recent progress, antiferromagnetic spintronics is still at its infancy with the field's full potential yet to be explored. We will conclude the lecture by outlining the rich symmetry and topology landscape that is now emerging by including antiferromagnets in spintronics to stimulate a renewed basic and applied research interest in these historically overlooked Néel's magnets.

Reference

Focus on Antiferromagnetic Spintronics, *Nature Physics* **14** (2018).

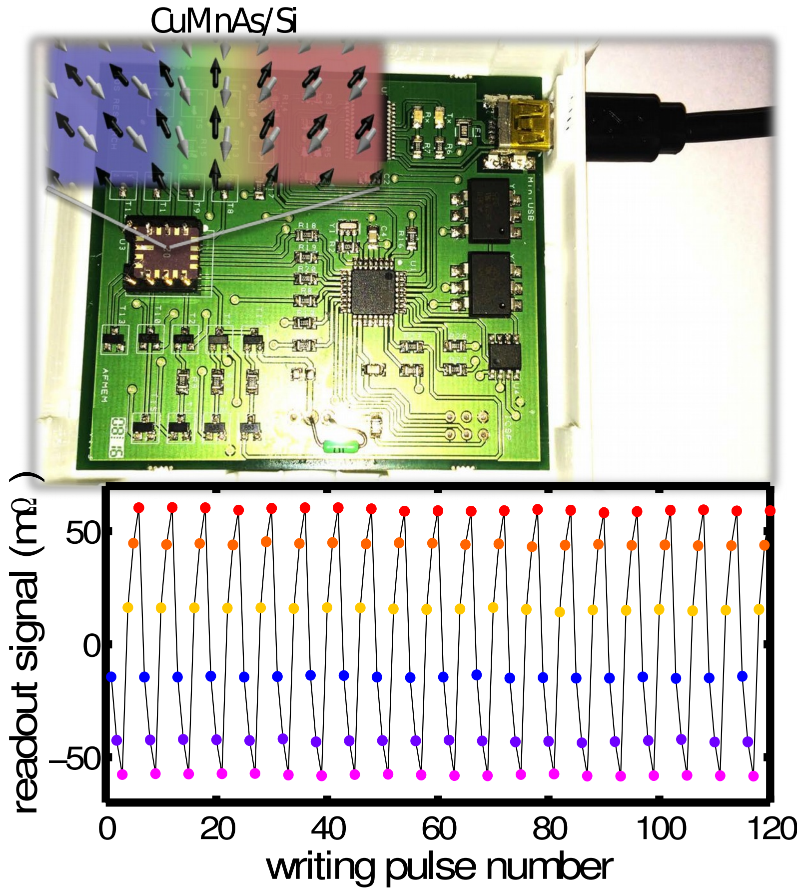

Figure. A memory bit cell fabricated on chip of an antiferromagnet-CuMnAs/Si, placed on a standard printed circuit board and connected to a computer by a USB port. Periodically, three successive writing current pulses along one direction are followed by three successive pulses along an orthogonal direction. Electrical readout after each pulse demonstrates a multi-level bit-cell characteristics.