STORING OR PROCESSING DATA WITH ANTIFERROMAGNETS?

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I. INTRODUCTION

Information technologies are nowadays especially receptive for novel building blocks that could help the transit beyond the Moore's law era. On these grounds, a plethora of candidate technologies have raised their proposals to stand in for covering specific portions of the ubiquitous Silicon technologies that nowadays are fairly covering from data storage (whilst in tight competition with magnetic media) up to data processing. At this moment of change, antiferromagnetic-based devices have emerged with quite an unprecedented momentum from the fundamental theories up to the academic sphere success in less than a decade. Now that the first round of academic demonstrations has been delivered [1,2,3], the moment to carefully choose where to focus the subsequent efforts and prevent an excessive economical and intellectual divergence has come.

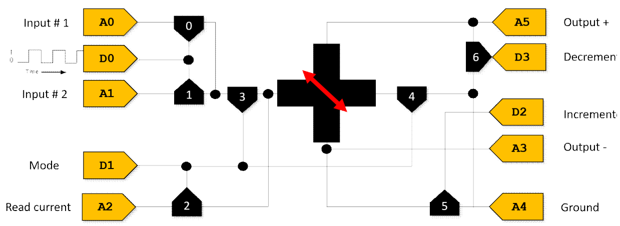

Figure 1. Schematic of an antiferromagnetic cross-shaped device in the center surrounded by contact pins (gold) and transistors (black). This building block fed with a clock signal input can be set to realize OR, XOR, AND, NOT, and a gradient of an analog input signal.

In this talk, we will first review the main features demonstrated so far by antiferromagnetic-based devices. Namely: the electrical switching at room temperature [4]; the realization of a USB-based desktop device capable of read/write intermediate resistive states and perform basic operations such pulse-counting and signal integration [5]; pushing the switching speed well into the picosecond regime by contact-less means [6].

After the state-of-the-art revision, we will present our core building block from which we will try to realize logic operations such as OR, XOR, AND, NOT and also some complex real-time operations such as the gradient of an analogic input signal. The schematic of the starting circuit geometry is shown in Figure 1. By setting the "mode", "incrementer" and "decrementer" pins to specific values, one can toggle among several functions. While this schematic does not represent a standalone device to be integrated immediately, it does represent the seed to initiate a dialogue with further integration steps.

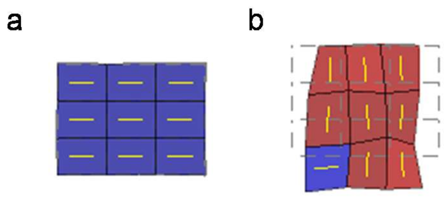

Figure 2. Scheme of the two perpendicular magnetic states after applying magnetic field along (a) north-south direction and (b) west-east direction in a magnetostrictive antiferromagnet. The difference between a and b can be sensed by electrical resistance measurements but the stray fields remain identical in both panels.

In the next section of the talk, we will compare the pros and cons of setting the heading of the antiferromagnetic spintronics field towards data storage, to data processing or to both – or to none.

Before concluding the talk, we will say a word on the progress of more fundamental aspects of the field that could also meet practical applications. Among these: the exploitation of magnetic invisibility of antiferromagnets for low-density security applications; the magnetoelastic coupling

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present in numerous materials that could be used for storing, encoding or even cloaking information (see Figure 2); and the state of the art of the magnetoelectric devices [7].

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