A hybrid Memristor/MTJ simulation framework for nano-oscillator devices.

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Nanoscopic systems with adjustable electrical properties composed by resistive and magnetoresistive random access memories (RAM) are very timely for storage and oscillator applications. Here, we designed and simulated a device where both the effects of resistive and magnetoresistive are combined to obtain high performant storage devices. The system is given by the series of an MgO based low resistive magnetic tunnel junctions (MTJs) and a memristor. MTJ is represented by a CoFeB free layer (thickness 1.6 nm) with magnetoresistance (TMR) ratios of about 100% and ellipse cross section of 150nm x 70nm [1] featuring perpendicular magnetic anisotropy (PMA). The memristor element is given as in Ref. [2] and it provides a functional relation between charge and flux $d\varphi = M dq$, where M is non-linear. In order to study the behavior of the whole device (considering both the effects of the memresistive and magnetoresistive), we developed a hybrid Memristor/MTJ simulation framework. The memristor is implemented in Spice using the Joglekar function. The micromagnetic part of the simulation tool is handled by a state-of-the-art macrospin solver, which numerically solves the Landau-Lifshitz-Gilbert-Slonczewski (LLGS) equation including the effect of the thermal field [3] and is implemented in Matlab [4]. In addition, a decoupling resistance (between 50 and 150 Ω) is connected between the two non-linear elements. The device is powered by a 1.2V-DC voltage applied to the series Memristor/ R(decoupling)/MTJ. We can observe that the temporal evolution of the output resistance is very clean and the microwave emission has a large output power, although it is excited at ultralow voltage and in the absence of any bias magnetic fields. The full paper will show the improvement in terms of linewidth and frequency characteristics at room temperature of the designed nano-oscillator.

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