L e c t u r e

"More-than-Memory functionalities of memristive BiFeO3 thin film structures"

of

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Abstract

We present the nonvolatile multilevel resistive switching in two-terminal Ti-doped BiFeO3 Metal-Insulator-Metal (MIM) structures up to 200°C without an electroforming process. The influential role of fixed Ti donors in BiFeO3 MIM structures was found in 2011 [1] and clarified in 2014 [2]. Fixed Ti donors can effectively trap mobile donors in BiFeO3. On the other hand, mobile donors can be redistributed between the two electrodes, if a voltage is applied and if the resulting electrostatic potential is larger than the Ti trap potential. Finally, the non-volatile resistance of the BiFeO3 MIM structures [3] is determined by the non-volatile distribution of mobile donors and enables MORE than MOORE functionalities of BiFeO3 as a post-silicon material, e.g. for energy-efficient neuromorphic sensors, detectors, and computer hardware. In a proof-of-principle experiment for learning we have shown that BiFeO3 MIM structures with one flexible and one unchangeable electrode reveal spike-timing dependent plasticity [4]. Furthermore, two-terminal BiFeO3 MIM structures with two flexible electrodes can be used for the nonvolatile reconfiguration of all 16 Boolean logic gates [5]. The trapping of mobile donors in BiFeO3 by fixed Ti donors enables the observed new functionalities of BiFeO3. If no voltage is applied, the non-volatile resistance of the BiFeO3 structures is determined by the non-volatile distribution of mobile donors. In addition, due to the electroforming-free and stable resistive switching of two-terminal BiFeO3 structures, validated memristance measurements could be performed [6] and also higher harmonics could be efficiently generated with a strong promise for application in a new type of hardware -based cryptography [7].

[1] Y. Shuai et al., Appl. Phys. Exp. 4 (2011); J. Appl. Phys. 109 (2011) [2] T. You et al., ACS Appl. Mater. Interfaces 6 (2014) [3] Y. Shuai et al., Phys. stat. sol. C 10 (2013); Scientific Reports 3 (2013); IEEE Electr. Dev. Lett. 34 (2013) [4] C. Mayr et al., Neural Information Processing Systems NIPS 2012 (2012); N. Du et al., Frontiers in Neuroscience (2014) submitted [5] T. You et al., Adv. Funct. Mater. 24 (2014) [6] N. Du et al, Rev. Sc. Instr. 84 (2013) [7] N. Du et al., J. Appl. Phys. 115 (2014)

Tuesday, 05.05.2015
Start: 1:00 p.m.

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