学 术 报 告

题目： Shaping Ferromagnetism in Diluted Magnetic Semiconductors with long-lived Bound Magnetic Polarons

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摘要：

The clear understanding of the transport and the optical properties of magnetic transition metal oxides (TMO) in an external magnetic and electric field [1] is important for future transparent spintronics. Advances in the fabrication of TMO materials make it possible to fabricate thin TMO films with a well controlled concentration of oxygen vacancies and with up to 10-20 at. % diluted magnetic ions. Since the 1960s TMO materials are used in transistors and nowadays high performance thin film TMO transistors with visible transmittance above 70% and mobilities up to 80 cm^2/Vs can be achieved with a maximum processing temperature that is compatible with flexible polymer substrates [2]. In the intrinsically n-type conducting TMO materials oxygen vacancies are used to make the TMO highly conductive. Often, very small changes in oxygen vacancy chemistry cause profound changes in TMO function, for example, inducing magnetization from a nonmagnetic state [3]. Since the prediction of room temperature ferromagnetism in magnetic semiconductors and magnetic TMOs, e.g. in p-type conducting Mn-alloyed ZnO [4] and despite huge efforts to clarify the role of dopants [5], the observed room temperature ferromagnetism in magnetic TMO is still a matter of controversy. Earlier magnetization measurements on magnetic TMO demonstrated that the ferromagnetism may be mediated by acceptor-like defects. Kittilstved et al. developed a theory for acceptor-mediated ferromagnetism in Mn-doped ZnO [6]. Coey et al. [7] proposed a ferromagnetic exchange mechanism involving oxygen vacancies (VO), which form F-centers with two trapped electrons. In most reports the increase of the low-frequency dielectric constant of magnetic oxides with increasing concentration of isovalent magnetic ions has been neglected. Therefore, the reported radius of bound magnetic polarons only represents a lower limit for magnetic oxides and the necessary concentration of oxygen vacancies for percolation of BMPs is overestimated. We have investigated the ferromagnetism in magnetic ZnO thin films with stable bound magnetic polarons (BMP) and have adapted the existing hydrogenic BMP model [7] to V_O^+ oxygen vacancies which form F^+ centers with one trapped electron. Furthermore, we have experimentally realized stable F^+ centers in magnetic ZnO and we have presented the fingerprints of ferromagnetism in magnetization and magnetotransport properties [8]. Magnetic oxides with stable BMPs will allow for new device approaches which exploit the huge internal magnetic fields felt by charge carriers in magnetic oxide films with F^+ center BMPs.

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报告人简介：

H. Schmidt from Technical University Chemnitz has completed her Ph.D in semiconductor physics at the University Leipzig in 1999. Since 2003 she heads the "Nano-Spintronics" group and develops artificial synapses for cognitive computing, magnetic oxide films for transparent spintronics, and smart carriers for live science applications. H. Schmidt has published more than 160 papers in peer-reviewed journals and served as an advisory program committee member for the international workshops subtherm-2011, WSE-2014, and WSE-2015. She received the Nano-Future prize from the Bundesministerium für Bildung und Forschung (2002) and a Heisenberg Fellowship from the German Science foundation (2011).

学术交流

题目：Unipolar and analog bipolar resistive and capacitive switching in multiferroic oxide thin films

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In the past decade, resistive switching (RS) and capacitive switching (CS) phenomena in multiferroic thin films have been widely investigated in the field of materials science, physics, and electrical engineering. Multiferroic materials, e.g. $YMnO_3$ [1] and $BiFeO_3$ have been considered as promising candidates for resistive and capacitive switching devices. This work investigates the RS properties of multiferroic $YMnO_3$ thin films reported to be unipolar resistive switches [2]. $YMnO_3$ was grown on $Pt/Ti/SiO_2/Si$ and Pt/Al_2O_3 substrates by pulsed laser deposition (PLD) as a polycrystalline film or as an amorphous one which was crystallized afterwards by flash lamp annealing (FLA) [3].

The multiferroic $BiFeO_3$ (BFO) has a large remnant polarization [4]. Here we investigate the field-driven capacitive switching in $BiFeO_3/Si_3N_4$/Ge/Si structures which has a lower power consumption in comparison to the current-driven resistive switching. BFO structures revealing resistive switching have been fabricated at 600 ^oC by PLD and by FLA recrystallization of amorphous BFO films for 20 ms in oxygen atmosphere [3].

BFO-based memristive switches have attracted increasing attention due to the fascinating resistive switching performance, e.g. electroforming free, multilevel resistive switching [5]. However, the underlying resistive switching mechanism is still controversial which restricts their practical applications. Here we develop a model on modifiable Schottky barrier height and elucidate the physical origin underlying resistive switching in Au-BFO-Pt/Ti memristive switches containing both fixed and mobile donors [6]. Increased switching speed is possible by applying a large amplitude writing pulse as the migration of mobile oxygen vacancies is tunable by both the amplitude and length of the writing pulse.

With the rapid progress in complementary metal-oxide-semiconductor (CMOS) integrated circuit technology, also a fast development of neuromorphic cognitive systems is expected. Spike-timing dependent plasticity (STDP) [7] with one pairing of a single presynaptic spike and of a single postsynaptic spike has been investigated in BFO-based resistive switches. The RS in BFO allows to adjust the synaptic weight of BFO-based artificial synapses in dependence on the time delay between the single pre- and postspike in both classical STDP with 60-80 single pairings [8] and novel STDP with one single pairing. Due to the easy pulse sequence in one single pairing STDP, the time delay could be reduced to few microseconds, memory consolidation in delay learning could be investigated, and energy consumption per SET process could be reduced to only 4.5 pJ [7].

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