MAR15-2014-020056

Abstract for an Invited Paper
for the MAR15 Meeting of
the American Physical Society

Optically-Induced Persistent Magnetization in Oxygen Deficient Strontium Titanate

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Interest in electronics and spintronics based on complex oxide materials has exploded in recent years, fueled by the ability to grow atomically-precise heterostructures of various oxides [1]. A foundational material in this burgeoning field is strontium titanate, a (nominally) non-magnetic wide-bandgap semiconductor. Owing to its ubiquity in oxide materials science, studies of $SrTiO_3$'s interesting dielectric, lattice, and optical properties represent mature research areas. However, renewed interest in $SrTiO_3$ was recently sparked by observations of unexpected *spin and magnetization* phenomena at interfaces between $SrTiO_3$ and other nonmagnetic oxides [1]. The formation and distribution of oxygen vacancies (V_O) in $SrTiO_3$ are widely thought to play an essential but as-yet-incompletely understood role in these emergent phenomena. Here we demonstrate a surprising new aspect to the phenomenology of magnetism in $SrTiO_3$ by reporting the observation of an optically-induced and persistent magnetization in slightly oxygen-deficient $SrTiO_{3-\delta}$ bulk crystals, using magnetic circular dichroism spectroscopy and optically-coupled SQUID studies [2]. This magnetization appears below 18K, persists for hours below 10K, and is tunable via the polarization and wavelength of sub-bandgap (400-500 nm) light. As such, magnetic patterns can be "written" into $SrTiO_{3-\delta}$, and subsequently read out, using light alone. This magnetism occurs only in crystals containing V_O, and is consistent with a metastable spin polarization of V_O-related defect complexes. These data reveal a detailed interplay between magnetism, lattice defects, and light in an archetypal complex oxide material, which may yield new insights into the recent exciting spin physics observed at oxide interfaces.

[1] see, *e.g.*: H.Y. Hwang *et al.*, Nat. Mater. **11**, 103 (2012); J. Mannhart & D.G. Schlom, Science **327**, 1607 (2010); MRS Bulletin **38**, 1017 (2013).

[2] W.D. Rice, P. Ambwani, M. Bombeck, J.D. Thompson, G. Haugstad, C. Leighton & SC, Nat. Mater. **13**, 481 (2014); ibid, J.Vac. Sci. Tech. B **32**, 04E102 (2014).