Optically-Induced Polarization Switching in $MoS_2/BaTiO_3$ heterostructures

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In recent years, the thickness of ferroelectric thin films has been pushing the limit of a few unit cells to enable a new type of ferroelectric-based devices, such as ferroelectric tunnel junctions (FTJs). The FTJ device structure is analogous to the traditional ferroelectric capacitors. However, the major difference is that the reading process is performed non-destructively through the electronic tunneling current measurements, which makes the FTJs faster and energy efficient.

Conventionally, a polarization state in ferroelectric devices is controlled by an electric bias. In this study, we demonstrate an alternative way to switch the polarization using optical excitation of hybrid $BaTiO_3$-based FTJs where we used a narrow-bandgap 2D semiconductor, molybdenum disulfide (MoS_2), as one of the electrodes. Bulk MoS_2 has an indirect bandgap of 1.2 eV, while monolayer MoS_2 is a semiconductor with a bandgap of 1.8 eV. As an initial step, we investigated the electrically-induced switching mechanism and polarization stability in $MoS_2/BaTiO_3$ hybrid heterostructures. Next, we demonstrated the UV light-induced polarization switching of the same heterostructures. It has been shown that the polarization switching direction of the $BaTiO_3$ layer strongly depends on the ambient due to the altered type of the screening charges in MoS_2. Polarization switching and retention behavior of the bare BTO films under UV illumination was used as a reference. The obtained results open a possibility for optical control of the electronic transport in memory and logic devices composed of 2D materials and ultra-thin ferroelectrics allowing reduced operation power and response time.