$EuTiO_3$: A Magneto-optical Device for Light Modulation

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Thin films of $EuTiO_3$ deposited on a $SrTiO_3$ substrate have been fabricated which are insulating and transparent with a band gap of 4.53eV. Both materials are non-magnetic at room temperature. The films have been shown to be single crystalline with the cubic c-axis in the growth direction. At T_S=282K $EuTiO_3$ changes from cubic to tetragonal symmetry thereby allowing the observation of birefringence Δn caused due to symmetry lowering. Below T*=190K an upturn in the birefringence signals another up to now unknown structural phase transition. Upon applying a magnetic field of only 0.02 Tesla, Δn can be tuned directionally whereby the magnetic field directed along the [110] direction completely suppresses it in contrast to the perpendicular direction [1$\bar{1}$0] where it remains active up to 240K. Along [100] and [010] the onset of Δn is observed below T_S as expected from symmetry considerations. An increase in the magnetic field to 0.1 Tesla leads to an enormous increase by a factor of 3 in Δn and a shift of its onset temperature from 240K to almost room temperature with the field being aligned along [1$\bar{1}$0] direction. In the perpendicular direction an enhancement of both Δn and its onset temperature take place, however much less pronounced compared to the [1$\bar{1}$0] direction. Simultaneously, prominent changes in Δn take place with the magnetic field being directed along [100] and [010], where the birefringence is suppressed above 190K in the [100] direction whereas it adopts a complex activity along [010] below TS.
From these data it is apparent that $EuTiO_3$ thin films are magneto-optically active and thus suited for device applications. The magneto-optical properties can be tuned by a magnetic field and temperature together with rotations of the sample and the magnetic field, respectively. An enormous sensitivity of Δn is observed along the [1$\bar{1}$0] direction where small changes in the magnetic field can enhance it by a factor of 3 and move its onset to temperatures around room temperature. Importantly, both film and substrate are macroscopically non-magnetic in the investigated temperature range.