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Polarization-dependent conductivity of grain boundaries in $BiFeO_3$ thin films

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Many efforts have been devoted so far to achieve the control of interfaces in ferroelectric materials based on their polarization. These efforts resulted in the discovery of a variety of different phenomena such as polarization-dependent tunneling effect, resistive switching, symmetry breaking, etc. [1, 2] In particular, domain wall conductivity [3], formation of topological defects [4], phase boundaries [5] and ferroelectric-insulator interfaces [6] have been studied. Charge transport across the interfaces in complex oxides attracts a lot of attention because it allows creating novel functionalities useful for device applications. In particular, it has been observed that movable domain walls in epitaxial $BiFeO_3$ films possess enhanced conductivity that can be used for reading out in ferroelectric-based memories [3]. In this work, the relation between the polarization and conductivity in sol-gel $BiFeO_3$ films with special emphasis on grain boundaries (GBs) as natural interfaces in polycrystalline ferroelectrics is investigated. The grains exhibit self-organized domain structure in these films (Fig. 1), so that the "domain clusters" consisting of several grains with aligned polarization directions are formed. Surprisingly, GBs between these clusters (with antiparallel polarization direction) have significantly higher electrical conductivity in comparison to "inter-cluster" GBs, in which the conductivity was even smaller than in the bulk. As such, polarization-dependent conductivity of the GBs was observed for the first time in ferroelectric thin films. The results are rationalized by thermodynamic modelling combined with finite element simulations of the charge and stress accumulation at the GBs giving major contribution to conductivity.

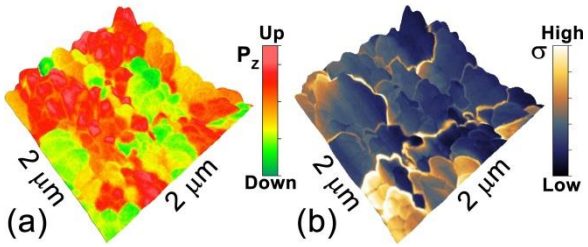

Figure 1. (a) Domain structure and (b) current response in $BiFeO_3$ sol-gel thin films.

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