Photon Polarization Dependence of Photocurrent in Multiferroic $BiFeO_3$ Thin Films

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1. Introduction

Conventional silicon-based solar cells generate photo-induced electron-hole pairs which are separated through an electric field created at the boundary of p-n junction. But, a ferroelectric material shows different photovoltaic mechanism. Ferroelectric domain walls play an important role in ferroelectric photovoltaic effect; it has been found that open circuit voltage can be increased without a limitation of band gap in proportion to the number of domain walls between two coplanar electrodes. $BiFeO_3$(BFO) is a material that has both ferroelectric and anti-ferromagnetic properties. It is G-type antiferromagnet and has a ferroelectric polarization along <111>. When BFO is grown on $DyScO_3$(DSO)$(110)_o$ substrate, two-variant stripe ferroelectric domain structure with highly-ordered 71° domain walls can be formed as a result of different in-plane lattice parameters of the substrate. We measured photocurrent of the BFO thin film through coplanar electrodes deposited on the top of the film. We report that the photo-induced short circuit current has dependence of light polarization. Whenever the light polarization is perpendicular to the stripe domain walls, the photocurrent can be maximized.

2. Experiment

BFO was grown on $DyScO_3(110)_o$ substrate by pulsed laser deposition(PLD) and we obtained well-ordered 71° domain walls. Electrodes were deposited so as to be parallel with domain walls. Linear polarized light (405 nm in wavelength) was illuminated on the film considering that the band gap of BFO is ~2.7 eV. We measured I-V curves rotating samples azimuthally fixing the linearly-polarized light. We measured the short circuit current rotating the inter-angle between photon polarization and ferroelectric domain walls.

3. Results

We plotted the short circuit current as a function of the inter-angle between photon polarization and ferroelectric domain walls. It shows the maximum short circuit current at the angle of 90° where photon polarization and ferroelectric domain walls align vertically.

4. Consideration

The inter-angle of 90° between light polarization and ferroelectric domain walls means that photon polarization is parallel to the net ferroelectric polarization.

5. Conclusion

Photon polarization dependence of photocurrent was measured. Parallel alignment of net polarization and photon polarization maximized photocurrent. The anisotropic photocurrent phenomenon suggests that the

well-aligned BFO domain walls can be potentially used for light polarization detector.

6. Reference

[1] S. Y. Yang. *et al.* Above-bandgap voltages from ferroelectric photovoltaic devices. Nature nanotechnology, 5, 143-147(2010)