Photo-striction in Ferroelectric materials

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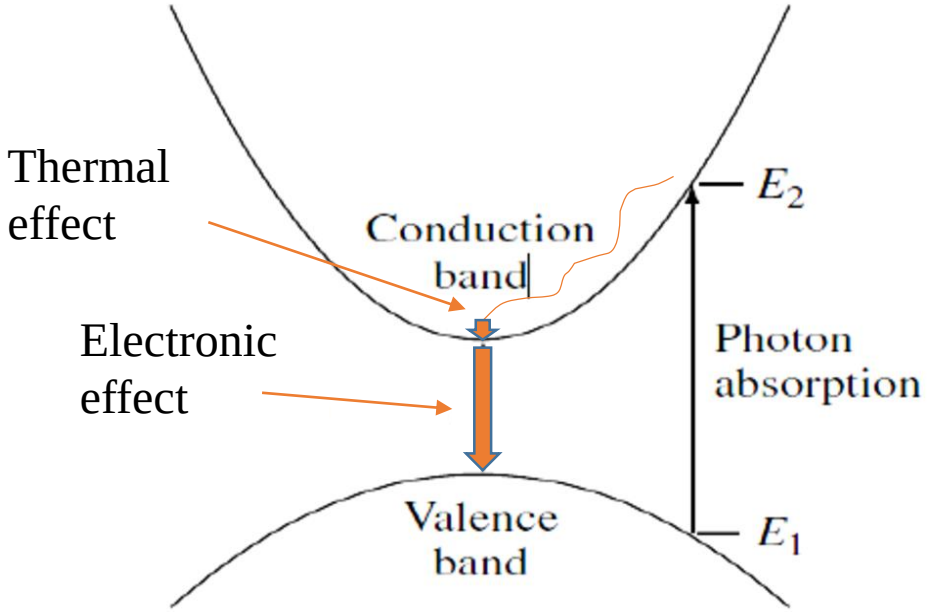
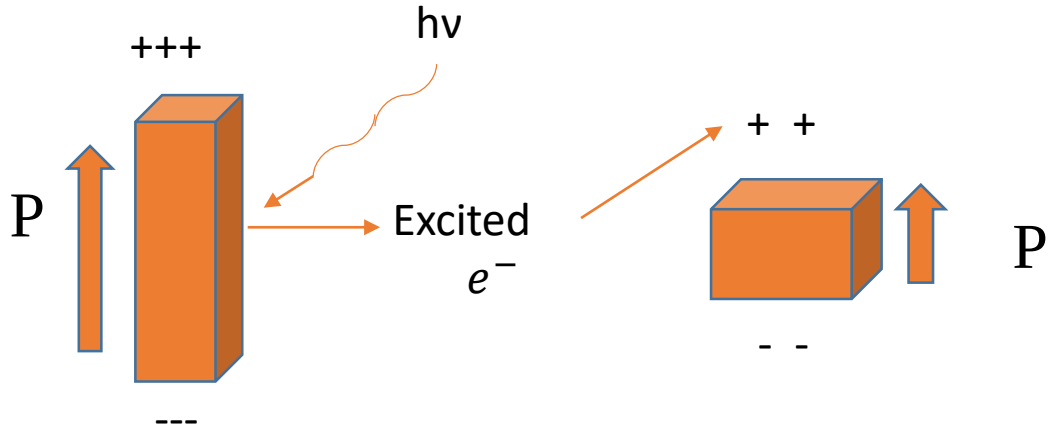
What is Photo-striction?

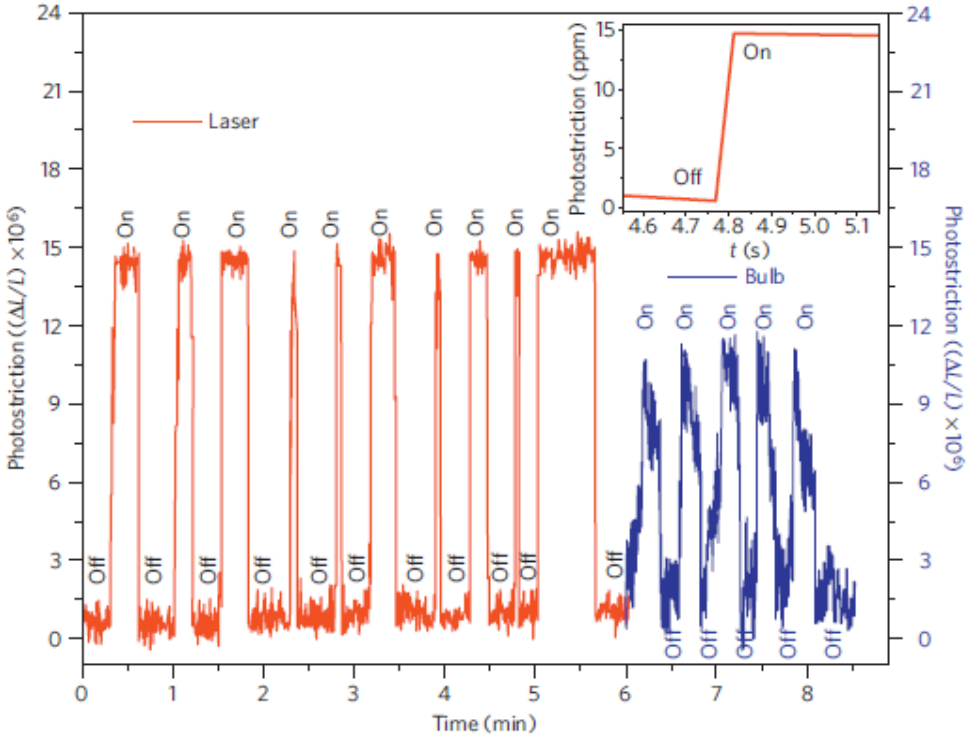
- Photostriction (PS) effect is a deformation of the material under light illumination.
- PS of ferroelectric materials originates from the combination of the screening of the polarization by the electrons photo ejected in the conduction band (photovoltaic effect)and the inverse piezoelectric effect.

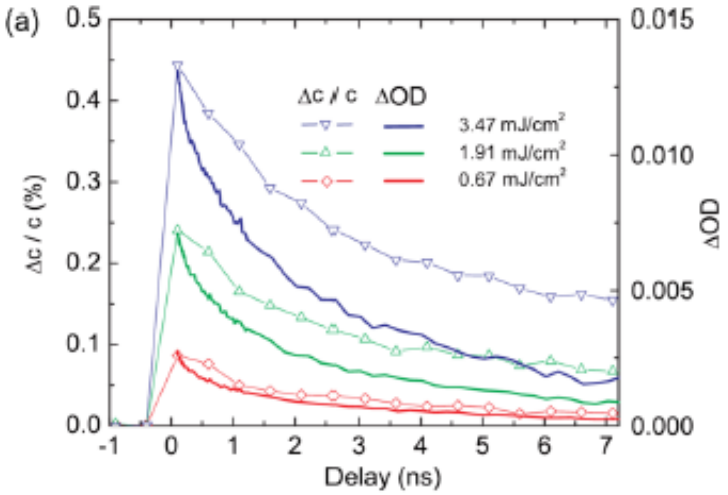




BiFeO3

- Crystal symmetry: R3c;
- Spontaneous polarization: 60uc/cm2
- Experimental method:
  - Pump-probe Xrd (3.2mJ/cm2, 400nm laser)
  - Capacitance dilatometer (15mW, 638nm laser)
- Change in lattice constant:
  - 4.4*10e-3
  - 15*10e-6
- Relax time:
  - 2-60ns
  - Response time < 0.1s





PbTiO3

- Crystal symmetry: P4mm; Spontaneous polarization: 40uc/cm2
- Experimental method:
  - Pump-probe Xrd (5mJ/cm2 (100GW/cm2), 400nm laser)
- Change in lattice constant:
  - - 1*10e-3
- Relax time:
  - Response time ~4ps

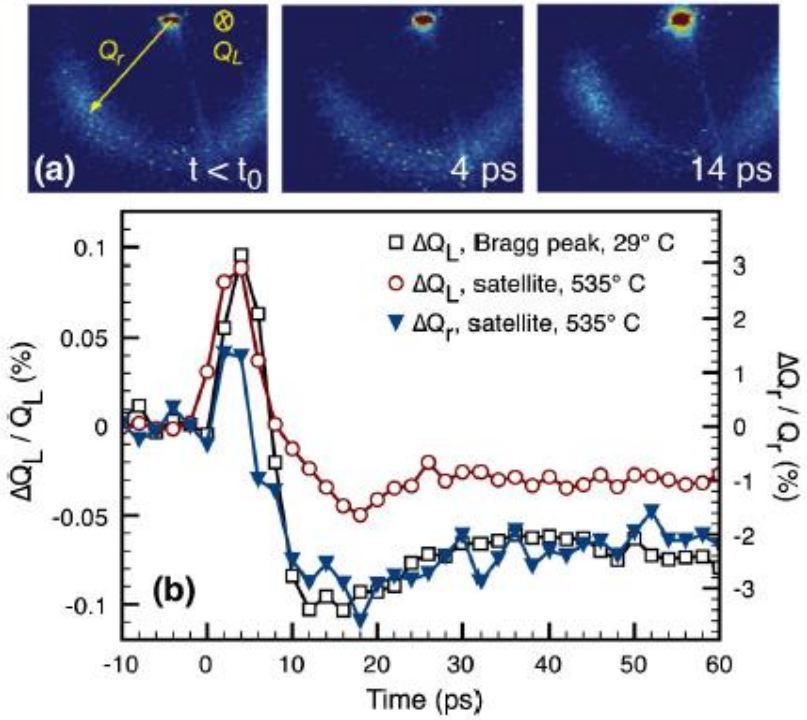


FIG. 2 (color online). Stripe domain phase response at 535 °C. (a) Area detector images of PTO (003) at 535 °C for several time delays (incident fluence = 5 mJ/cm^2), corrected such that the angle of the detector plane is normal to the L axis in reciprocal space. (b) Time evolution of Q_L and Q_r, extracted from area detector images of PTO (003). Q_L is the position of the diffuse scattering ring along the L axis and Q_r is the radius of the diffuse ring.

SbSI

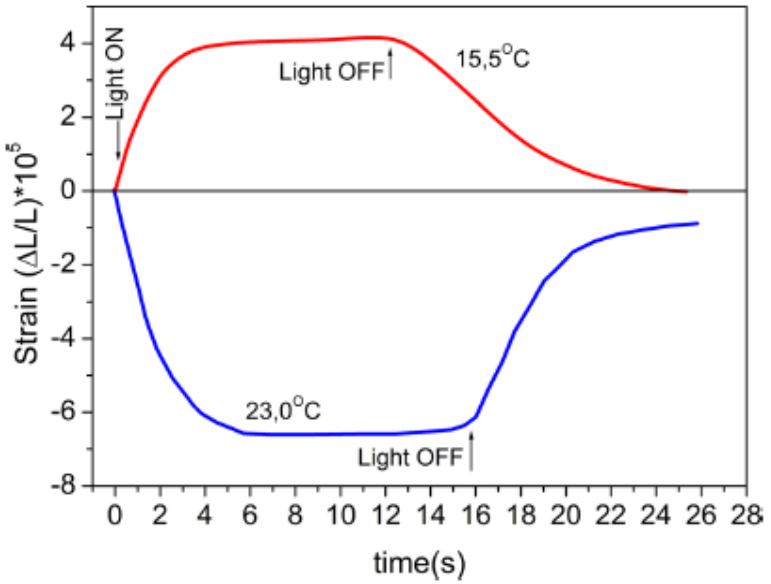
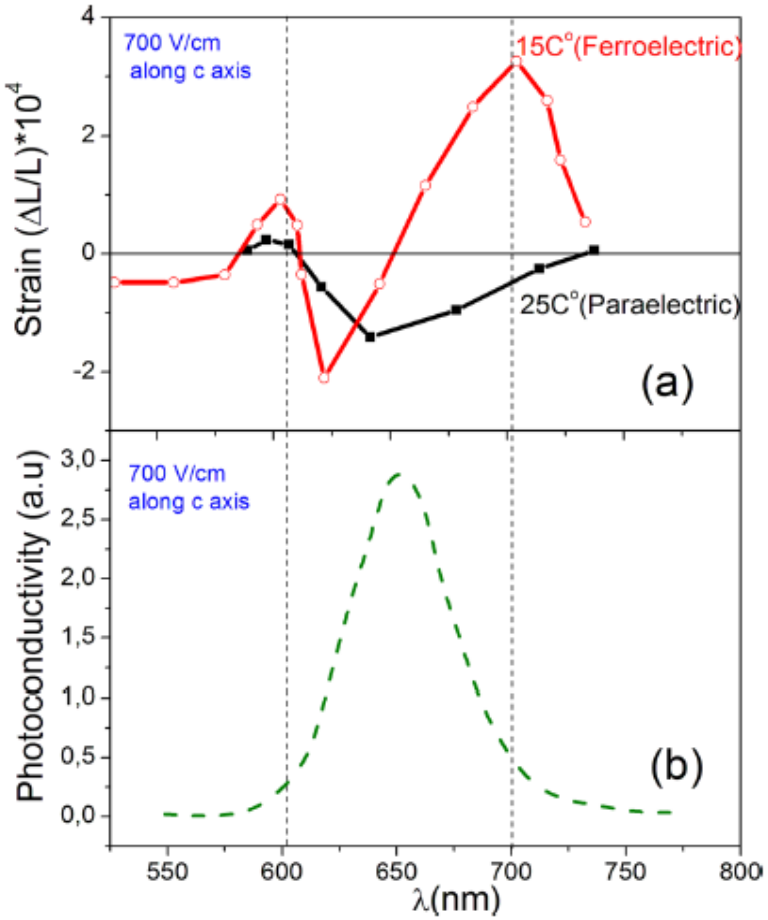


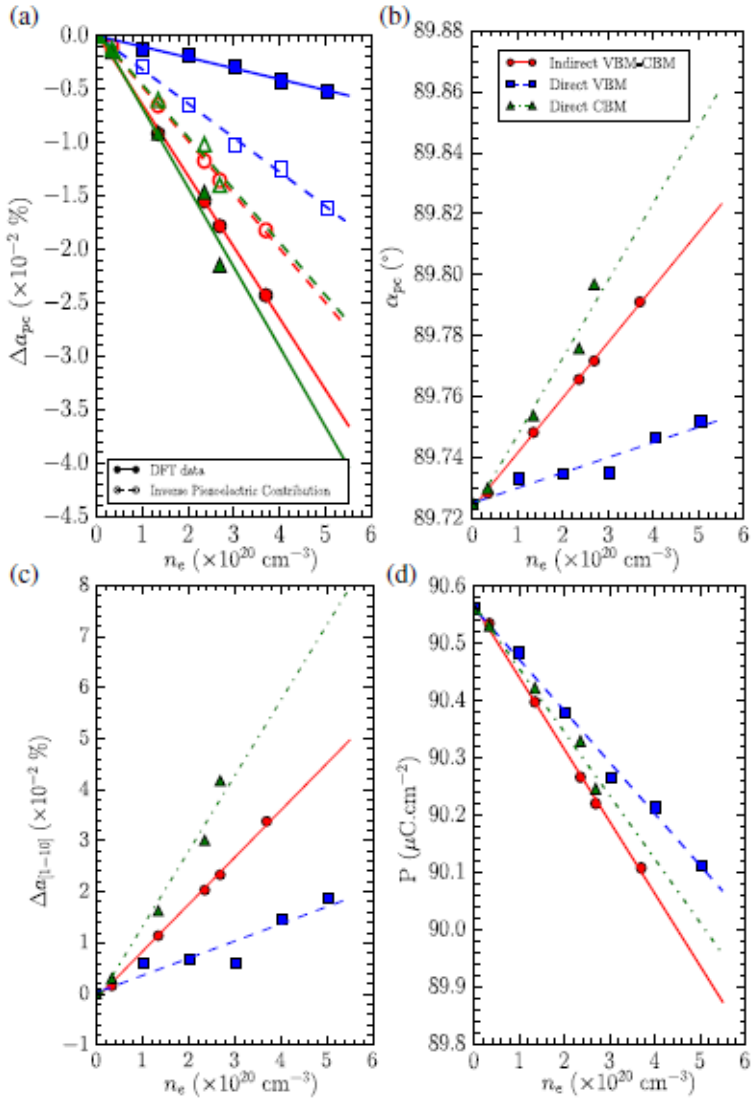
FIG. 1. Photostriction of SbSI single crystals along the c axis at electric field of 1 kV/cm. The 450 nm wavelength and gold electrodes were used. Reprinted with permission from Tatsuzaki *et al.*, Phys. Rev. Lett. **17**, 198 (1966). Copyright 1966 The American Physical Society.



At the near-paraelectric (25 C) state, it is a consequence of electric field screening by light generated charges as an electric polarization averages to zero in the near-paraelectric state.

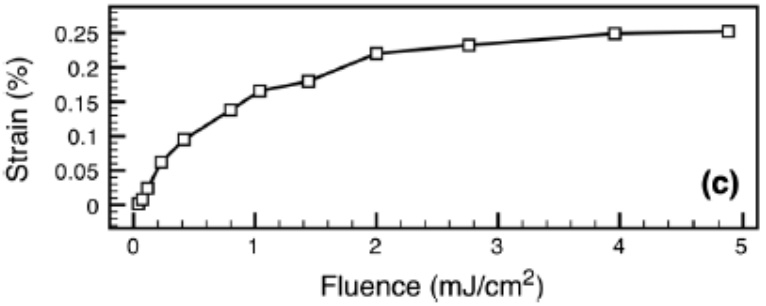
In the ferroelectric region, however, it is two competitive contributions: electric field redistribution leading to increment of electric field and electric field screening by the light generated charges leading to decrease of electric field in the sample.

DFT simulation of BFO



"good agreement": linearity
But **sign** is wrong!

Experimental data
Strain change with fluence (exited electrons)



Conclusion?

- What is the real Photostriction effect due ferroelectric property?