Investigation of photovoltaic response in brownmillerite multiferroic $KBiFe_2O_5$ thin film

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Brownmillerite structured Multiferroic $KBiFe_2O_5$ (KBFO) is a promising photoactive material for subsequent optoelectronic applications due to its smaller bandgap and intrinsic polarization. Herein, we reported the preparation, optical and electrical properties of the KBFO thin film. The phase confirmation of KBFO thin film prepared by a simple spin coating technique was characterized by X-ray diffraction (XRD) pattern. The surface morphology as well as thickness of the KBFO thin film deposited on FTO coated glass was identified by scanning electron microscopy (SEM). The bandgap of KBFO film was investigated by UV-Vis spectroscopy which extends visible to the infrared region compared to conventional perovskite-structured multiferroic. The evidence of photovoltaic responses in KBFO device was explained based on Current-Voltage characteristics under dark as well as visible light illumination. In summary, the intrinsic polarization and photo absorption properties in KBFO could be regarded the material as a suitable candidate for ferroelectric photovoltaic applications.

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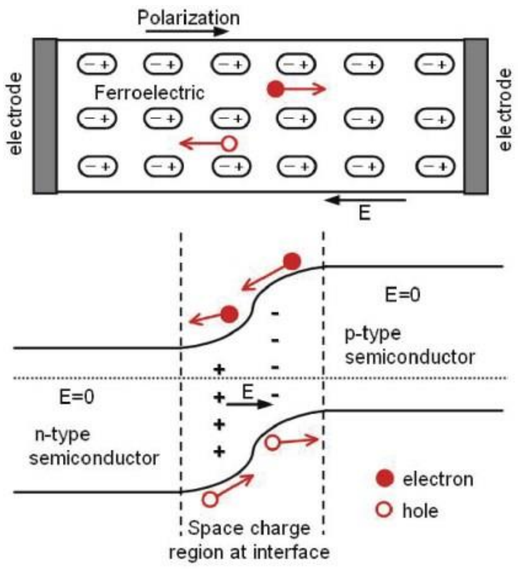
INTRODUCTION



- PV responses can be generated without forming p-n junction
- V_{oc} is not limited to below the band gap can lead energy conversion efficiencies to beyond the maximum value (~34%)
- Photo-voltage can be enhanced or reversed by electrical poling
- These materials. are thermal, moisture and operational stable , nontoxic, cheap and earth abundant
- The output signals of ferroelectric photovoltaics (FEPVs) can be tuned by various other means
- Compatible with many other functional compounds

- The advantage of ferroelectric photovoltaics (FEPV) is the generation mechanism of the internal electric field, also called photo-ferroics, which distinguishes them from conventional p-n junction semiconductors.

EXPERIMENTAL TECHNIQUES

- The X-Ray diffraction (XRD) : Rigaku) Ultima-IV, CuKα radiation λ = 1.5418 Å
- The surface morphology and thickness : Nova Nanosem 450
- Absorbance spectra - UV–visible absorption spectroscopy
- The Raman modes of vibrations - room temperature Raman Spectroscopy
- The photoresponse - Keithley 2400 sourcemeter and solar simulator with a power of100 mW/cm²

- New Brownmillerite structured Multiferroic $KBiFe_2O_5$ (KBFO) is a promising material with characteristic oxygen-deficient perovskite structures.
- It features low band gap compared to other perovskites.

RESULTS AND DISCUSSION

STRUCTURAL AND MORPHOLOGICAL ANALYSIS

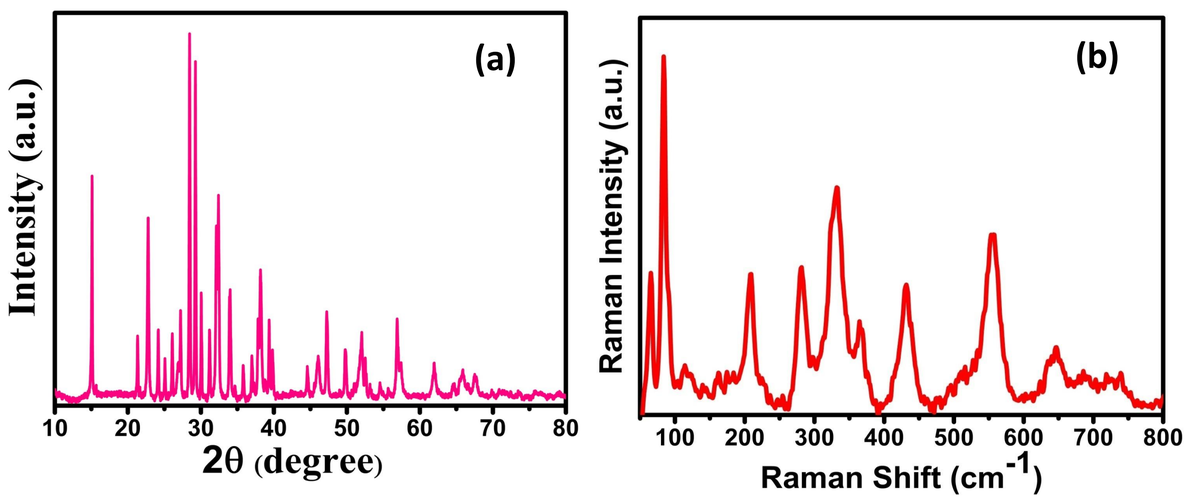


Fig.1. (a) XRD pattern (b) Raman Spectra of KBFO thin film

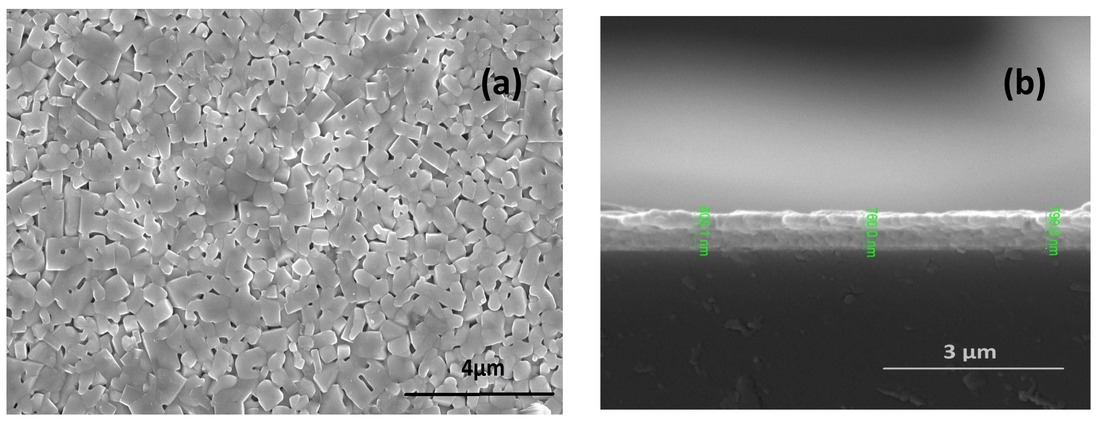


Fig.2. (a) Surface Morphology (b) Thickness of KBFO thin film

- Fig.1.(a) shows the XRD patterns of the sample calcined at 873K confirm the formation of orthorhombic phase KBFO. The average crystallite size of KBFO thin film were calculated from the Scherer formula and found to be 90 nm.
- The characteristic peak of Raman spectroscopy shown in Fig.1.(b) gives the information about the vibration of molecular bonds with respect to the interaction of light with chemical bonds within the materials.
- FSEM image shown in Fig.2.(a) signifies that KBFO nano-particles have a regular shape and uniformly distributed throughout the film.
- The thickness of the KBFO thin film varies between 700 nm to 800 nm.

OPTICAL AND ELECTRICAL ANALYSIS

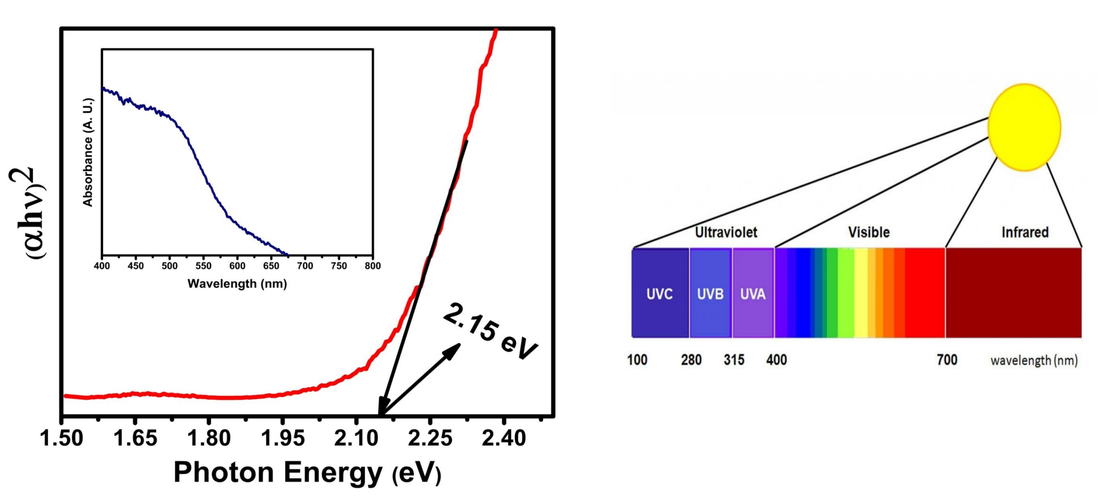


Fig.3. UV-Vis absorption Spectra of KBFO thin film

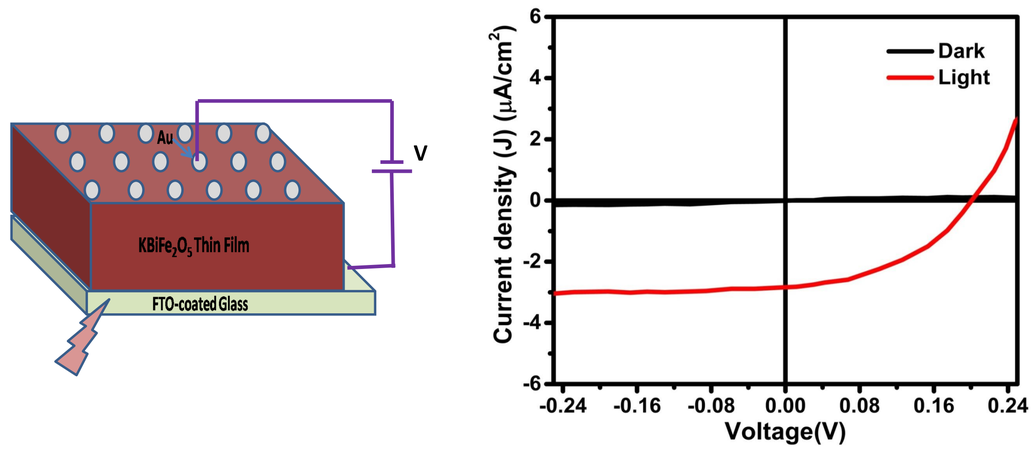


Fig.4. Current-Voltage characteristic curve of KBFO thin film deposited on FTO-coated substrate

- Fig.3 shows A broad absorbance spectrum suggests that KBFO has a pretty good ability to response light energy and the band gap was evaluated around 2.15 eV.
- The Current-Voltage characteristic curve of $KBiFe_2O_5$ film shown on Fig.4 reveals the photovoltaic effect in both dark and illumination conditions.
- The open circuit voltage (V_{OC}) and short-circuit current (I_{SC}) were evaluated to be around 0.22 V and 2.91 μA, respectively.
- The Fill Factor and efficiency were calculated as 0.42 % and 2.44×10^{-4} % respectively.

CONCLUSION

- An achievable, low cost, environmental friendly rout was adopted for the preparation of KBFO.
- It has been observed that KBFO responses visible light simultaneously generates the photovoltaic effect due to its intrinsic polarization.
- It was expected that by modifying the absorber layer based on ferroelectric materials, the device performance can be improved in a reasonable manner.
- This work highlights photo-ferroics behavior of KBFO which can be effectively utilized for various applications such as optoelectronic and photovoltaic devices.

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