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Piezo response of defects mediated Methyl Ammonium Lead Iodide ($MAPbI_3$)

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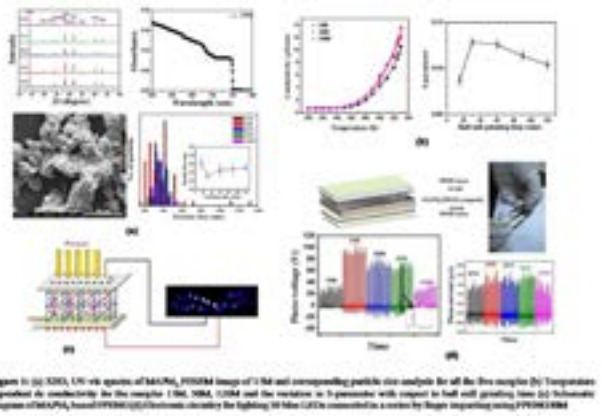
Formation of lattice defects (point defects/dislocations/grain boundaries) is an unavoidable phenomenon which is associated with almost all synthesis procedures following fast formation kinetics. Therefore a polycrystalline thin film of hybrid perovskite developed for a solar cell invariably contains lattice defects. Similarly in a systematic fashion using ball mill grinding technique we have synthesized perovskite material, Methyl Ammonium Lead Iodide ($MAPbI_3$) with different degrees of crystal defects as probed by Positron Annihilation Spectroscopy (PAS) and utilized to Fabricate Flexible Piezoelectric Nano Generators (FPENGs). Five sets of $MAPbI_3$ samples are prepared by ball mill grinding procedure with different grinding time (15m, 30m, 60m, 90m and 120m). The formation and morphology of $MAPbI_3$ is confirmed from their powder XRD pattern and field emission scanning electron microscopy (FESEM) images. The optical band gaps (1.63 eV) of all the samples are calculated from their absorption onset at 760 nm. The x-ray diffraction pattern suggests the formation of tetragonal crystal phase. We have demonstrated that at room temperature the lattice defects play the pivotal role in governing the ionic polarization from temperature dependent dc conductivity measurement and establish one-to-one correlation with the lattice defects as probed by PAS, which in principle governs the piezo-effect in $MAPbI_3$. Here, we have shown that lattice defect mediated ionic polarization significantly changes VOC, but ISC remains almost same for all the samples as ISC has its origin on the value of piezoelectric constant and elastic modulus of the material. The best device performance is exhibited by maximum defect containing sample (30m) having significant amount of Pb^{2+} defects. A device fabricated with 5 wt % PDMS composite produces piezo-voltage (>100V) with a maximum power density of 0.3 mW/cm^3 and can illuminate commercially available 30 blue light emitting diodes.



Recent Publications

1. Dhar J, Sil S, Dey A, Sanyal D, Ray P P (2017) Investigation of ion-mediated charge transport in methyl ammonium lead iodide perovskite. The Journal of Physical Chemistry C 121(10):5515-5522.
2. Dhar J, Sil S, Dey A, Ray P P, Sanyal D (2017) Positron annihilation spectroscopic investigation on the origin of temperature-dependent electrical response in methyl ammonium lead iodide perovskite. The Journal of Physical Chemsitry Letters 8(8):1745-1751.
3. Prochowicz D, Franckevicius M, Cieslak M A, Zakeeruddin M S, Gratzel M, Lewinski J (2015) Mechanosynthesis of the hybrid perovskite CH3NH3PbI3: characterization and the corresponding solar cell efficiency. Journal of Materials Chemistry A 3(41):20772-20777.
4. Williams Spencer T, Zuo Fan, Chueh Chu Chen, Liao Chien Yi, Liang Po Wei, Jen Alex K Y (2014) Role of chloride in the morphological evolution of organo lead halide perovskite thin films. ACS Nano 8(10):10640-10654.

Biography

Partha Pratim Ray is working as an Associate Professor in the Department of Physics, at Jadavpur University, Kolkata, India. He has done his PhD and Postdoctoral research work on thin film silicon based solar cell. He is working on synthesis and application of different nanostructured materials in energy harvesting devices. He has studied the effect of different synthesis methods on charge transport properties which determines device performance. He is also working on metal organic framework based thin film photosensitive Schottky diode. .

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