Abstract

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Thesis title: "Development of some novel nanocomposites for energy harvesting applications".

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A novel piezoelectric sensor is fabricated by a composite with all-inorganic cesium lead bromide ($CsPbBr_3$), cesium lead chloride ($CsPbCl_3$) perovskite rod and multimetallic oxide ($CuCoNiO_4$) embedded polyvinylidene fluoride (PVDF) polymer matrix that enables nucleation of electroactive β phase in PVDF >86% and makes it suitable for piezoelectric energy harvesting. Piezoelectric energy generation from the devices has been investigated under several simple human movements like hammering by hand, finger touch, toe pressing, bending by arm and so on. Optimized composite (5 wt. % $CsPbBr_3$ containing PVDF film) based PNG delivered an output power of 4 mW with high open-circuit voltage of 120 V and short-circuit current of 35 μA. In addition, the photosensitivity of the composite is demonstrated under light, which promises its potential as a photodetector. Considering the photoresponse and electroactive features, a new class of self-powered photoactive piezoelectric energy harvesters has also been fabricated. Incorporation of $CsPbCl_3$ in the PVDF matrix enables high crystallinity and nucleation of electroactive β-phase ~86% in the PVDF with piezoelectric coefficient d_{33} of 49 pm/V. The fabricated PNG delivered an instantaneous output voltage of 168 V and a peak-to-peak output current of 2 μA. The high sensitivity of the flexible PNGs enables us to measure even a slight deformation due to bending by 2°. Considering its good flexibility and high electrical output performance, optimized PNG was utilized for the fabrication of a wearable self-powered posture sensor to monitor the regular movement of our spine. Walking-based wearable PNGs are also devised for powering up normal android mobile phone batteries. Also, the combination of $CuCoNiO_4$ as filler creates a notable electroactive phase inside the PVDF matrix, and the composite realized by combining 1wt% $CuCoNiO_4$ with PVDF exhibits the highest electroactive phase (>86%). Under periodic hammering (~100 kPa), PNGs fabricated with this optimized composite film deliver an instantaneous voltage of ~67.9 V and a current of ~4.15 μA. Furthermore, PNG is ingeniously integrated into a supercapacitor to construct PSCFS, using PNCU as a separator and $CuCoNiO_4$ nanowires on carbon cloth as the positive and negative electrodes. Piezoelectric nanogenerator based on polyvinylidene fluoride (PVDF) and aligned zinc oxide (ZnO) nanorods is fabricated for mechanical energy harvesting. ZnO nanorods array over zinc foil was realized via facile wet chemical method at ambient conditions. As fabricated device showed an open-circuit voltage of ~21.5 V and instantaneous power of ~135.45 μW at an applied pressure of 4.5 MPa. Generated output power was more than sufficient to glow commercial green LEDs.

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