Development of Highly Efficient and Environmentally Friendly CsSnI3 Perovskite Materials for Solar and Thermoelectric Energy Harvesting

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In the past 100 years, rapid climate change from fossil fuel use has caused continuing problems, such as a 30% reduction in crop production and up to 140°F temperatures in some regions. Clean energy is a promising alternative. However, current solutions suffer from low efficiency and toxicity issues. Thus, the purpose of this project was to develop $CsSnX_3$ (X= I, Br, Cl) perovskites to determine which of them is the best for renewable energy generation, and reveal which of these dopants: bismuth (Bi), antimony (Sb), or carbon quantum dots (CQD), gives the best electronic properties. The perovskite halides were first studied computationally using Density Functional Theory (DFT). Out of the three materials, CsSnI3 was shown to have the optimum bandgap and lowest thermal conductivity, which is ideal for solar and thermoelectric energy harvesting. Thin films of CsSnI3 were then fabricated using spin coating, followed by doping with Bi, Sb, and CQD. Next, in order to verify the structure of the materials, the four samples were characterized by SEM, EDS, XRD, and Raman spectroscopy. The thermoelectric (TE) properties of the doped materials were then measured. CsSnI3:CQD was found to have the best TE properties, which led to a high TE figure of merit (ZT) of 1.24. This displayed an increase in efficiency of 125% from the intrinsic material. This perovskite material features novelty, high-efficiency and environmentally friendly elements. It is also multipurpose, as CsSnI3:CQD, may be applied in various areas such as solar energy harvesting, thermo-electrics, and potentially supercapacitor application.

Awards Won:

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