Effective Bi Doping on CdTe Solar Cells

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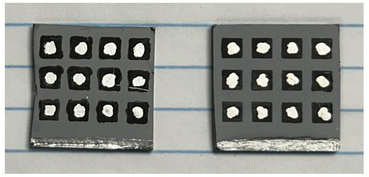
Abstract

This research initiates from Copper doping as a preliminary validation step. Once manufacturing and characterization methods are refined, Bi doping will be conducted with modified procedures. Then, the most significant phase of the study, characterization mechanisms such as Photoluminescence (PL), Time-Resolved Photoluminescence (TRPL), External Quantum Efficiency (EQE), and CV graphing progress.

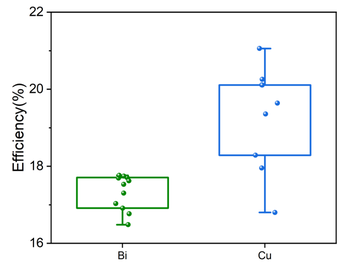
Procedure

The fabrication process of Cu-doped and Bi-doped CdTe solar cell panels was carried out as follows. Each substrate was first cleaned by immersing in NH_4OH, followed by HCl. For Cu doping, a $CuCl_2$ solution was dynamically spin-coated on the sample. For Bi doping, a bismuth nitrate solution was dynamically spin-coated for the sample. The Cu-doped samples were annealed at 230°C for 5 minutes, while the Bi-doped samples were annealed at 260°C for 5 minutes. After annealing, both Bi-doped and Cu-doped samples were cleaned with HCl to remove organic compounds and eliminate surface oxides. Graphene was then applied to all samples, followed by drying. For the Bi sample, it went through a 300°C post anneal process for 5 minutes. Then, tin solder was applied to the samples. Finally, a layer of silver was deposited on all samples to enhance conductivity and protect the carbon layer.



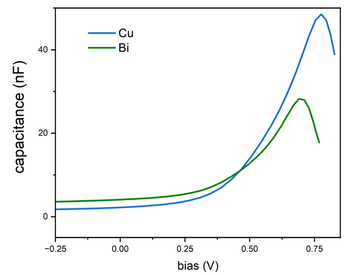
A picture of the devices.

Efficiency



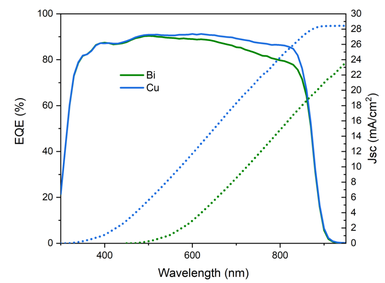
Most nodes of the Cu-doped cell has higher efficiency than the ones on the Bi-doped cell.

CV



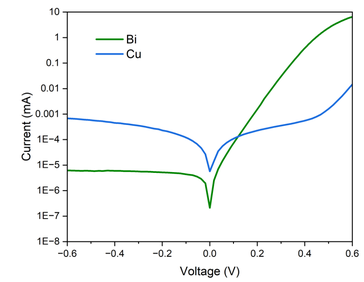
Bi doping results in thinner depletion width and higher carrier density

EQE



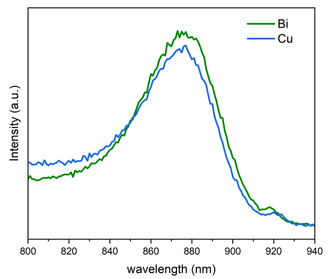
Comparing to Bi's EQE drop around 800nm, Cu's EQE has slower decay, which indicates better junction quality.

Dark IV



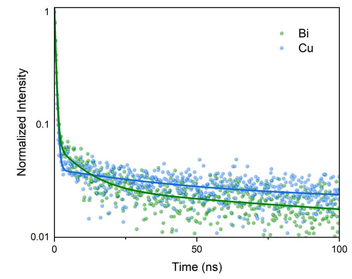
Bi-doped cell displays a steeper slope and higher leakage current, suggesting less junction blocking at the interface.

PL



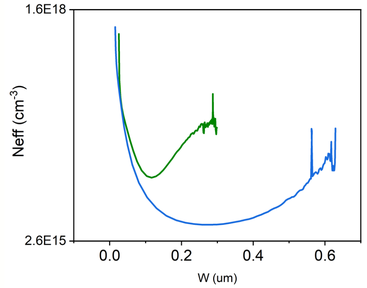
Bi-doped CdTe exhibits higher photoluminescence intensity compared to Cu-doped CdTe, indicating more efficient radiative recombination and reduced non-radiative losses caused by defects.

TRPL



Cu-doped cell has a longer carrier lifetime than Bi-doped cell, suggesting reduced recombination rates.

Doping Efficiency



The doping for Bi is stronger and more localized near the junction.

Results

In conclusion, although copper has higher efficiency, other graphs prove that comparing to copper, bismuth still has high potential to become a superior dopant for CdTe solar cells. After discussion and literature review, manufacturing a high-performance bismuth-doped device requires precise annealing process. Overall, this work demonstrates promising results but still bears considerable potential for further optimization and improvement.

FURI

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