III-V-based semiconductor devices: Sustainability strategies for critical elements in high-efficiency optoelectronic energy materials

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Epitaxial semiconductor layer structures involving III-V compounds, germanium, and silicon promise highest performance levels in PV applications such as in solar cells and photoelectrochemical cells [1-3]. This can be achieved, since optimum absorber layers, band gaps and advanced contact formation can be engineered. Hence, multi-absorber structures with III-V semiconductors show excellent optoelectronic properties and record performances in all kinds of photovoltaic materials, electronic and opto-electronic devices, direct solar hydrogen generation, or CO_2 reduction. However, the group-III element indium is in limited supply (at the level of silver); gallium can also be considered critical and some group-V elements such as arsenic and antimony are also hazardous to health. The aims of our approach are (i) reduction, substitution, and recycling of critical elements in III-V device structures, e.g. by increased use of aluminum and reduction of atomic lattice constants, (ii) more efficient use of materials in improved device structures such as nanowire and quantum well structures, (iii) substrate substitution (germanium substrate reuse) and III-V on silicon growth, and (iv) life cycle analysis and economic perspectives for the fabrication of III-V based optoelectronic devices. I will also address latest progress on the important III-V/Si interface, improved analysis and modifications by fine-tuning of the preparation.

References

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