New routes to highest conversion efficiencies: III-V semiconductor structures on silicon

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Epitaxially prepared, monolithically integrated layer stacks have been demonstrated to display the highest performance in basically all optoelectronic device structures as in the field of solar energy conversion - in photovoltaics [1] as well as in direct solar-driven water splitting systems [2]. In these record-breaking multi-layer structures, interfaces are the most crucial parts in different regards. To accelerate progress in these fields, it is essential to gain an atomic-scale understanding of critical and essential heterojunction preparation, including the complex physico-chemical processes and interface formations [3-6].

In order to reduce costs and to realize competitive high-performance multi-junction stacks for solar cells or water splitting devices structures without employing concentrator technology, the concept of III-V semiconductor integration into silicon technology refers to one of the most topical and generic issues regarding challenging heterointerfaces. An interface with low-defect density between silicon and III-V compounds would be a major breakthrough and would not only add to solar energy conversion, but all kinds of opto-electronic devices. III-V-on-Si growth relates to the difference in atomic structure, which manifests itself in the polarity of the III-V material as opposed to the non-polar nature of the silicon substrate. Here, original analysis will be presented to scrutinise state-of-the-art preparation and to develop efficient solar energy conversion routes.
Also, nanowire device structures with axial or radial heterojunctions could open new opportunities and contribute added values to next generation photovoltaic concepts such as lower material consumption, easier transfer on silicon substrates, multi photon absorption, etc. Planar GaP epilayers on Si(111) are considered as virtual substrates for III−V-related nanowire-based optoelectronic devices such as high-efficiency nanowire-based tandem absorber structures for solar energy conversion, next generation LEDs, and fast photodetectors. Here, rotational twin domains in such heteroepitaxial epilayers are found to strongly impede vertical nanowire growth.

References

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