Area 3: III-V Compound Semiconductor and Concentrator and Space PV Technologies

HIGH EFFICIENCY PHOTOVOLTAICS ENABLED BY III-V MATERIALS

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III-V multi-junction solar cells have proven to be the most efficient photovoltaic technology. Triple-junction devices power modern space satellites and find niche markets in unmanned vehicles or drones. But a wider terrestrial use depends on the ability to reduce cost substantially. The combination of a 2-6 µm thin III-V absorber with a silicon bottom cell (instead of germanium) enables high efficiency at reduced cost. We demonstrate 2-terminal GaInP/AlGaAs/Si triple-junction solar cells reaching up to 32.4% AM1.5g conversion efficiency. These devices are realized by direct wafer bonding of the III-V absorbers to silicon, leading to a fully integrated device structure. III-V material use can be further reduced in nanowire devices which are manufactured by partners at the Lund University and at Sol Voltaics. Together we are investigating the benefits of combining a 1.7 eV GaInP or GaAsP nanowire top cell with an infrared sensitive 1.1 eV silicon bottom cell. This allows substantial cost reduction due to the small surface coverage of the III-V nanowires. Finally, concentrators are another way to substitute expensive III-V material by cheaper lenses or mirrors. At concentration levels of 500 and above, this technology has shown to be close to competitiveness and multi-MW power plants have been realized. High concentration PV comes with additional complexity due to the optical concentrator and precise 2-axis tracking. Therefore, high solar cell efficiencies are key to enhance the overall power output. Here, the use of more complex 4-junction device structures is beneficial, reaching up to 46 % conversion efficiency at a concentration level of 312-suns. We will discuss current progress made in these different fields of development.

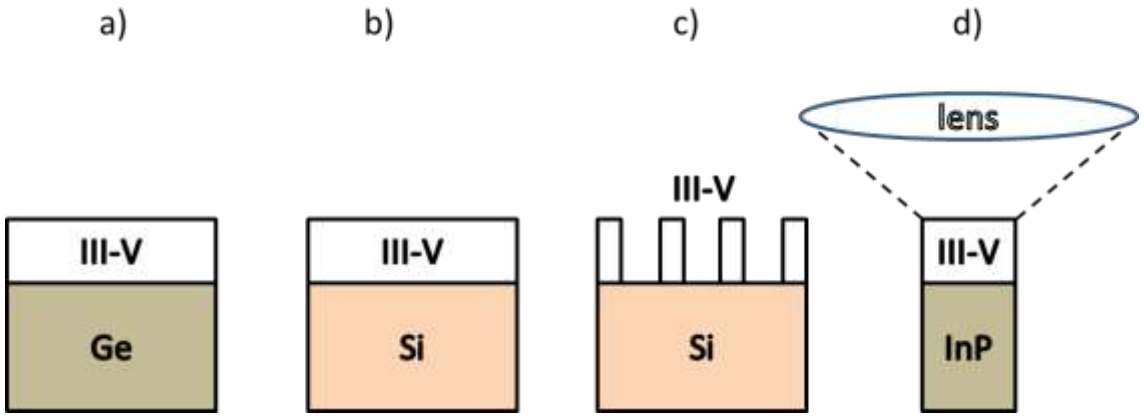

Figure 1: Approaches for cost reduction of III-V multi-junction solar cells: a) conventional III-V cell on Germanium, b) III-V solar cell on silicon, c) III-V nanowire cell on silicon and d) concentration of sunlight to reduce III-V material use.

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