Indium Phosphide Nanopillar Solar Cells Grown on Silicon Substrates

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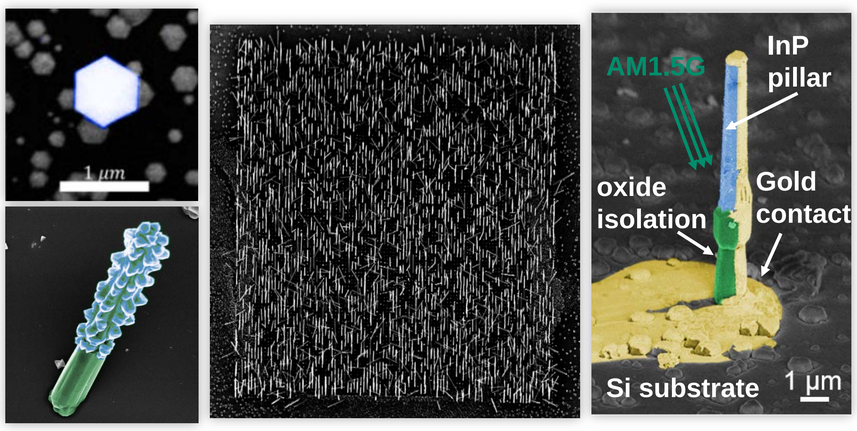
PHOTOVOLTAICS

III-V nanopillars on silicon: Overview

- III-V absorbers produce highest conversion efficiencies, but substrate costs for homoepitaxy can be expensive.
- Silicon substrates- inexpensive and scalable.
- Growth of III-V nanopillars (InP, InGaP, InGaAs) on lattice-mismatched silicon substrates.

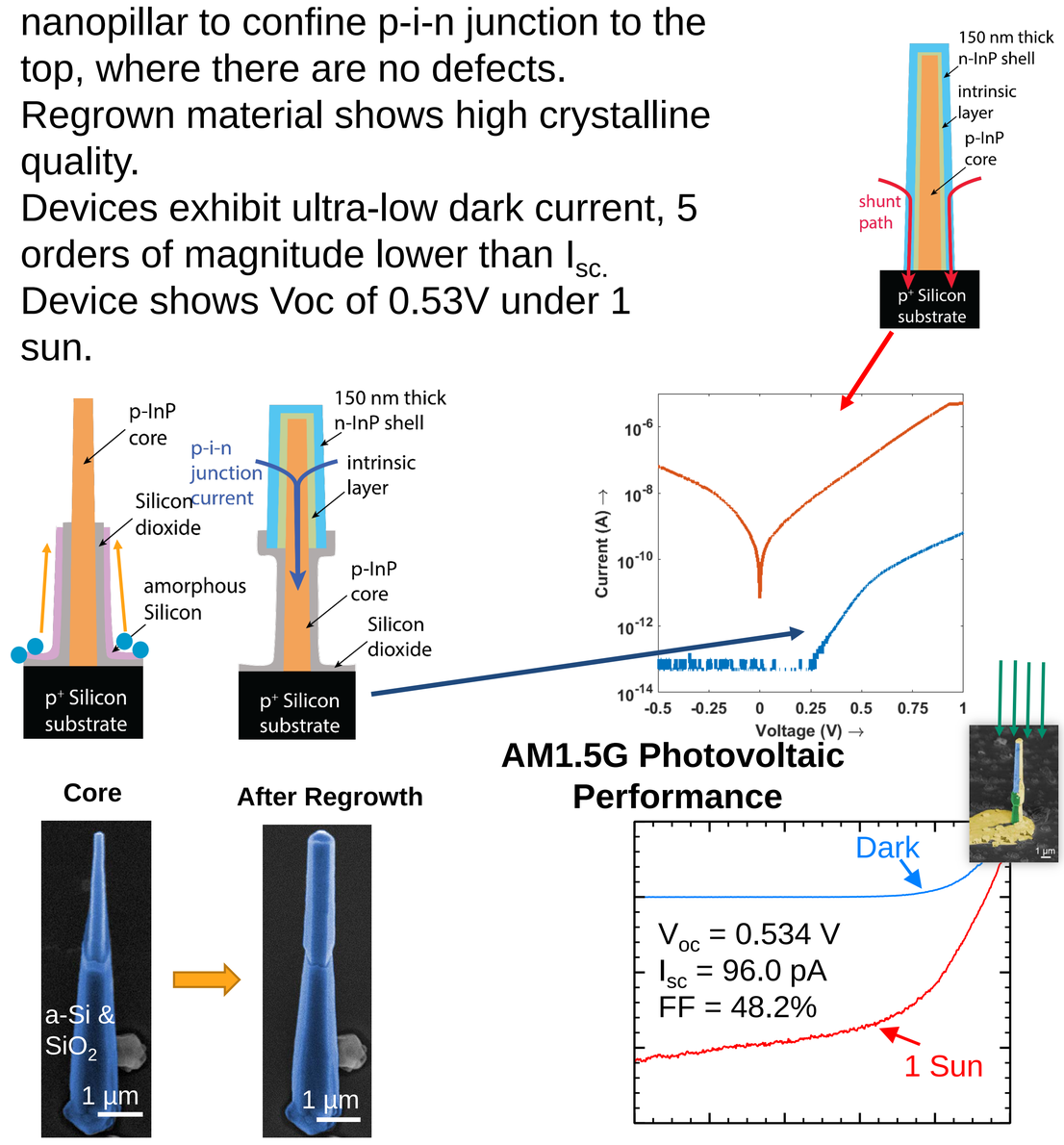


Tran et. al., "High brightness InP micropillars grown on Silicon with Fermi level splitting larger than 1 eV", Nano Lett., 2014, 14(6)

- InP and InGaP nanopillars were grown by metal organic chemical vapor depositions (MOCVD).
- Core-shell growth (radial) growth mode allows nanopillar diameters larger than 1 um for better surface to volume ratio.
- InP nanopillars have low surface recombination velocity , ideal material for photovoltaics.
- Surface texturing can improve light absorption: 1 sun Fermi level split> 1 eV.
- Single pillar and ensemble devices have been fabricated.

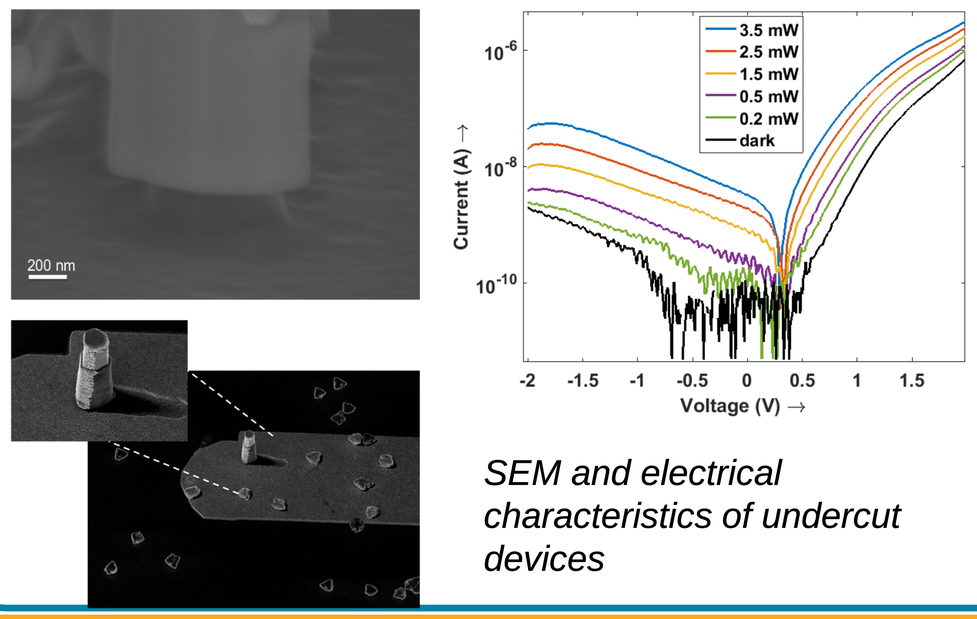
Regrowth process: placement of junction and electrical isolation.

- Regrowth performed on upper part of nanopillar to confine p-i-n junction to the top, where there are no defects.
- Regrown material shows high crystalline quality.
- Devices exhibit ultra-low dark current, 5 orders of magnitude lower than $I_{sc.}$
- Device shows Voc of 0.53V under 1 sun.



InP nanopillar based devices with silicon undercut

•InP based p-i-n junctions were grown on n-doped silicon.
•Thin shell of p-InGaAs was grown for better electrical contact and reduced series resistance.
•Si substrate was etched using SF6+O2 plasma etch to create electrical isolation between the p-shell and n-doped substrate.
•Devices shows a lower series resistance of 40 KΩ.
•Reverse dark current shows reduction by two orders of magnitude (10^{-10} A).



SEM and electrical characteristics of undercut devices

Site-controlled growth of nanopillars on silicon

- .Nanopillars can be nucleated under precise controlled positions
- Mask for site-controlled growth on silicon: 125 nm of SiO_2.
- Nanopillar array pitch can be varied from 1um-50 um
- Nanopillars grown in selective areas show good optical quality with 30% smaller linewidth compared to spontaneous ones.

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