

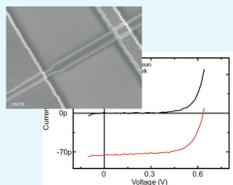
# Towards flexible GaAs Nanowire solar cells

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## PiN Junction

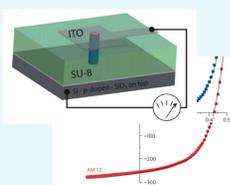
- Horizontal



The nanowire has been removed from the substrate and deposited for contacting.

Colombo et al, Appl. Phys. Lett. (2009)

- Vertical

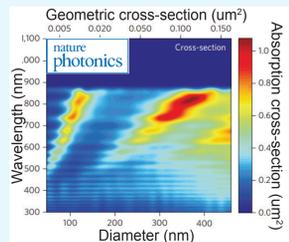


The nanowire has been contacted as grown on Si (111) substrate with ITO.

Krogstrup et al, Nat. Phot. (2013)

## Nanowire Properties

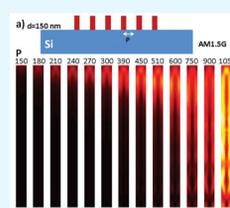
- Enhanced Absorption



The absorption cross-section can exceed up to 10x the geometrical cross-section. Nanowire acts as natural light concentrator.

Krogstrup et al, Nat. Phot. (2013)

- Reduced Material Consumption

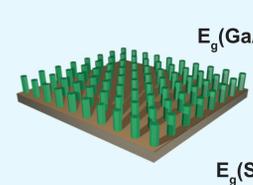


In radial PiN-junctions the full length of the nanowire is used for carrier generation and carrier extraction.

Heiss et al, Nanotech. 25, 1, 014015 (2014)

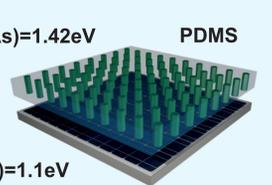
## Objective

- Tandem



**Advantages:** Monolithic integration.  
**Disadvantages:** Series connection.

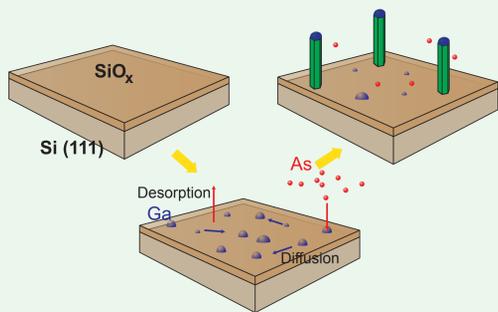
- Mechanically Stacked



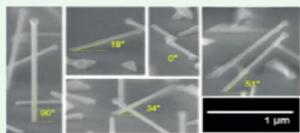
**Advantages:** Parallel connection.  
**Disadvantages:** Additional processing.

## Mechanism

### Vapor Liquid Solid (VLS)



The growth process is Ga-catalyzed, driven by self-assembly. Ga forms the liquid phase, whereas As gets adsorbed the catalyst, until supersaturation, triggering nanowire growth.



The lack of polarity of Si, together with 3D twinning allows multiple orientations.

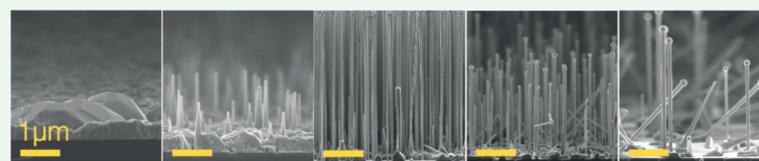
Uccelli et al, Nano Letters, 11, 9, 3827 (2011)

## Growth Insights

1) Etch



2) Wait

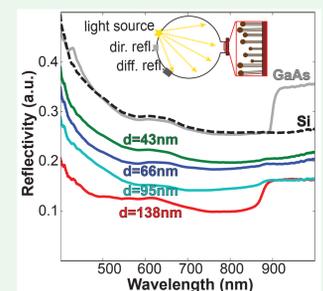


0.5      0.7      0.9      1.2      1.5

Oxide Thickness (nm)

Matteini et al, Submitted (2015)

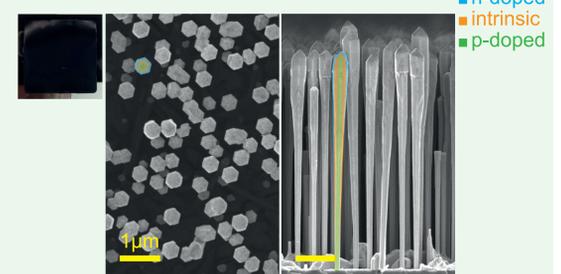
## Engineer Light Absorption



Matteini et al, Nanotechnology 26, 105603 (2015)

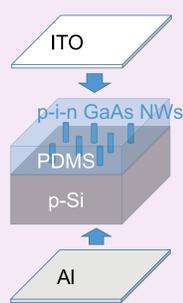
Tailoring nanowire diameter and density allows engineering light absorption.

### Arrays of PiN junctions



## Device Fabrication

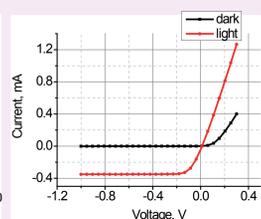
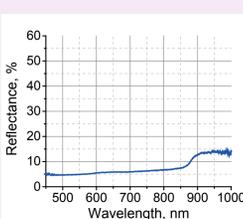
Developing of pilot devices for analyzing GaAs p-i-n structures



Device scheme



SEM image of device surface with NWs.

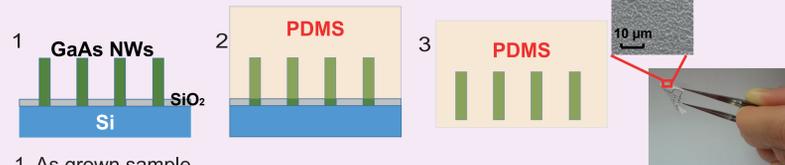


-Reflectance of device surface is below 10% in the visible because of rough top surface (see SEM image above).

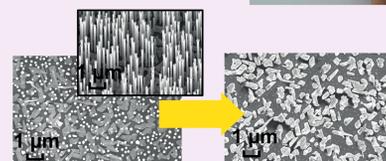
-Typical current-voltage characteristic shows diode nature of the device.

## PDMS-NW Composite

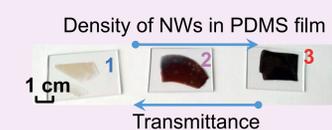
Embedding NWs into PDMS - process steps



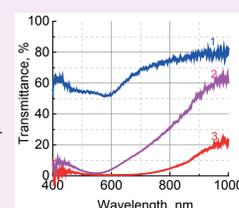
1. As grown sample  
2. Spin-coating of PDMS solution on sample.  
3. Peeling of PDMS-NW composite from Si substrate.



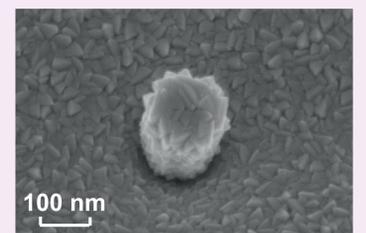
Successful peeling of NWs from substrate.



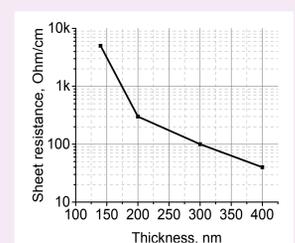
By changing NW density, transmittance of PDMS-NW composite can be optimized for effective work of tandem GaAs NW/Si solar cell.



## Front Contact Design



Top SEM image of PDMS-NW composite covered by ITO (thickness - 140nm)



ITO sheet resistance strongly depends on thickness. With increasing thickness of ITO, the size of the micro-crystals increases leading to lower resistivity.

## Acknowledgments

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