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James P. Connolly, Jean-Paul Kleider, Alexandre Jaffré, Denis Mencaraglia, Laurie Dentz, et al.. Modelling textured GaAs nanocrystals on silicon for III-V/Si tandem solar cells. Journées nationales du Photovoltaïque (JNPV) 2024, Dec 2024, Dourdan (91), France. <hal-05296198>

HAL Id: hal-05296198

<https://hal.science/hal-05296198v1>

Submitted on 3 Oct 2025

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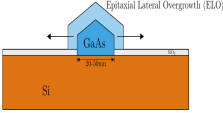
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Modelling textured GaAs nanocrystals on silicon for III-V/Si tandem solar cells

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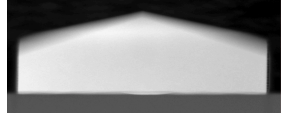
Concept and modelling strategy



Concept 1: ELO GaAs on Si tandem

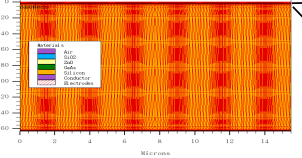
The structure :

- Front surface contact : $\approx 20\text{nm}$ conformal TCO coating
- GaAs cell(s) $\approx 1\mu\text{m}$ separation $\approx 0.5\mu\text{m}$
- Silicon oxide interlayer $\approx 2\text{nm}$
- SiOx seed pit for GaAs growth $\approx 2\text{nm}$ deep x 50nm wide
- Tunnel or recombination layer $\approx 10\text{nm}$ layers
- Silicon cell $\approx 160\mu\text{m}$ absorber (p $1\text{E}15/\text{cm}^2$)
- Other properties as BISON cell ²



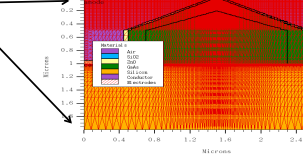
Example 1: GaAs microcrystal on Si 111

Model mesh :

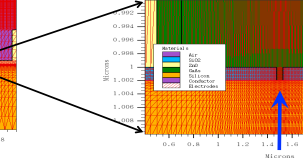


Lame scale : Multilane GaAs periods

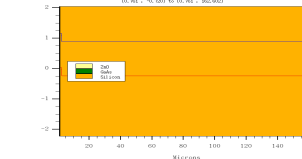
GaAs scale one period shown (2 wide x 1 high) μm

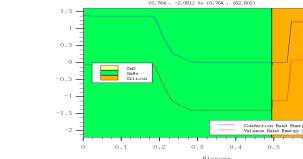


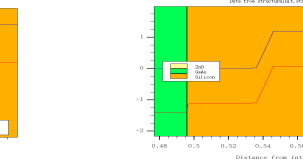
Interface : GaAs seed (2x50)nm, tunnel junction²



Model bands:



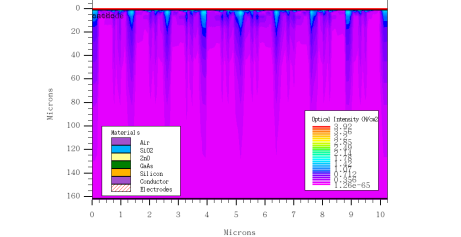




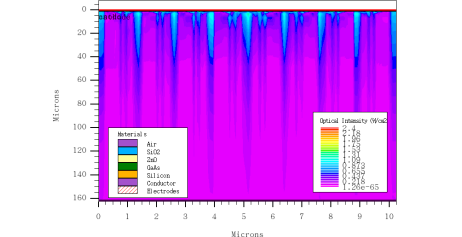
Method : Standard drift diffusion ; NLBBT quantum tunnel ; Ray tracing.
Limitations : **Model limitations :** Complete structure not (yet) simulated - **Processing limitation :** Ray tracing rather than FDTD

Light management : GaAs ELO crystals as surface texturing

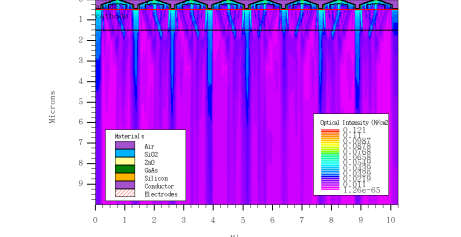
700nm light: GaAs absorbs, weak light scattering to Si



950 nm : GaAs transmits, strong Light scattering to Si



Broad AM15G spectrum : Zoom on 8 GaAs period

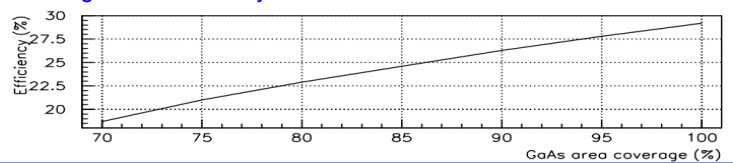


GaAs subcell area coverage and size study

Partial GaAs coverage of Si subcell - tandem efficiency trend :

- photons best absorbed in high gap are transmitted to low gap
- increased thermalisation : Tandem efficiency gain is less

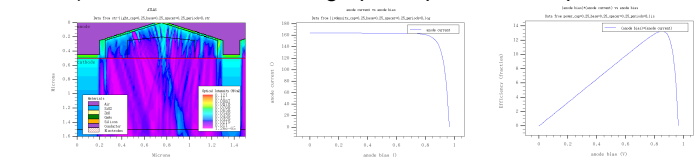
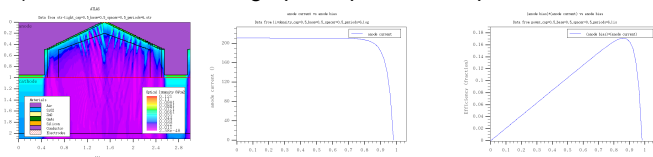
=> \approx Linear increase in tandem efficiency with GaAs coverage



Crystal size : incomplete GaAs absorption for small crystals :

1) GaAs : 2 wide x 1 high μm separation $0.5\mu\text{m}$: **17%**

2) GaAs : 1 wide x 0.5 high μm separation $0.25\mu\text{m}$: **13%**



=> Larger crystals better absorption, smaller crystals better coverage

=> **Compromise between coverage and absorption**

Conclusions :

- A tandem with built-in light trapping
- Defect free III/V on silicon growth
- Next steps : simulator update resolve model limitations

[1] L. Dentz et al., "Development of Monolithically Integrated (Al)GaAs on Silicon for Tandem Solar Cells", EU PVSEC 2023, DOI:10.4229/EUPVSEC2023/2CV.2.26, <https://hal.science/hal-04789460v1>

[2] C. David et al., "Comparative Simulations of Conductive Nitrides as Alternative Plasmonic Nanostructures for Solar Cells", Energies 2021, 14(14), 4236; <https://doi.org/10.3390/en14144236>

[3] C. Renard et al., "High current density GaAs/Si rectifying heterojunction by defect free Epitaxial Lateral overgrowth on Tunnel Oxide from nano-seed", Sci.Rep.(Nature) 2016; doi: 10.1038/srep25328, www.nature.com/articles/srep25328

Acknowledgements: The Hello_PV project is funded by the French Agence Nationale pour la Recherche under the program ANR-22-CE50-0011-01