III-V/SI MULTI-JUNCTION POTENTIAL FOR SPACE

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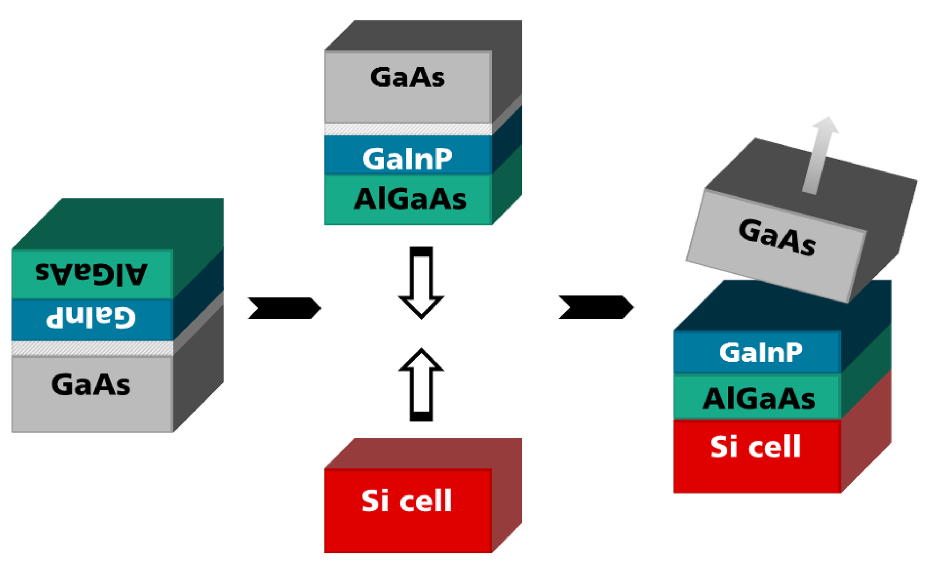
Motivations

- III-V/Si: a new technology combining the high performance III-V materials with the low cost large scale silicon PV industry

Why using III-V/Si in space can be attractive ?

Efficiency	+ III-V/Si record devices reach similar effiencies than the standard GaInP/GaAs/Ge cells [1]: ➢ 2-terminal 3J GaInP/GaAs/Si: 33.3% AM1.5g [2] ➢ 4-terminal 3J GaInP/GaAs/Si: 35.9% AM1.5g [3]
Mass	+ With 2.3 g/cm^3, Si density is more than 2x lower than Ge
Radiation hardness	- Si less radiation hard than Ge in standard space conditions + Ge cell degrades strongly in LILT, low light low intensity[4]
Thermal expansion	+ Smaller CTE compared to Ge
Cost	+ Si more abundant & significantly cheaper than Ge - III-V/Si efforts needed to bring the manufacturing cost down

III-V/Si wafer bonded multi-junctions



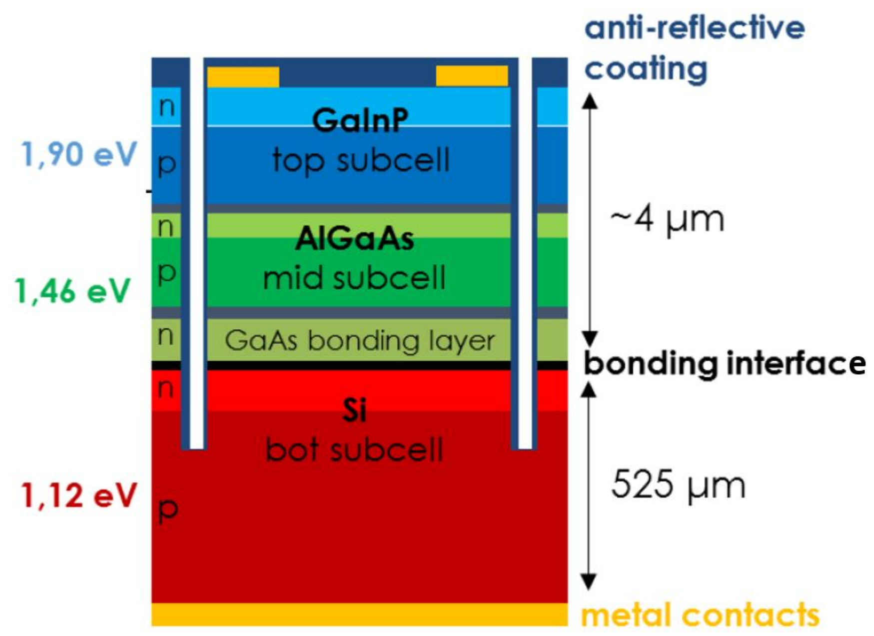
i) GaInP/(Al)GaAs III-V cells lattice-matched grown inverted on GaAs

Fraunhofer ISE   IQE

ii) n-Si emitter formation, n-GaAs surfaces sputtering, III-V and silicon wafers pressed together [5]

iii) III-V substrate removal, Si rear-side & III-V front side processing [5]

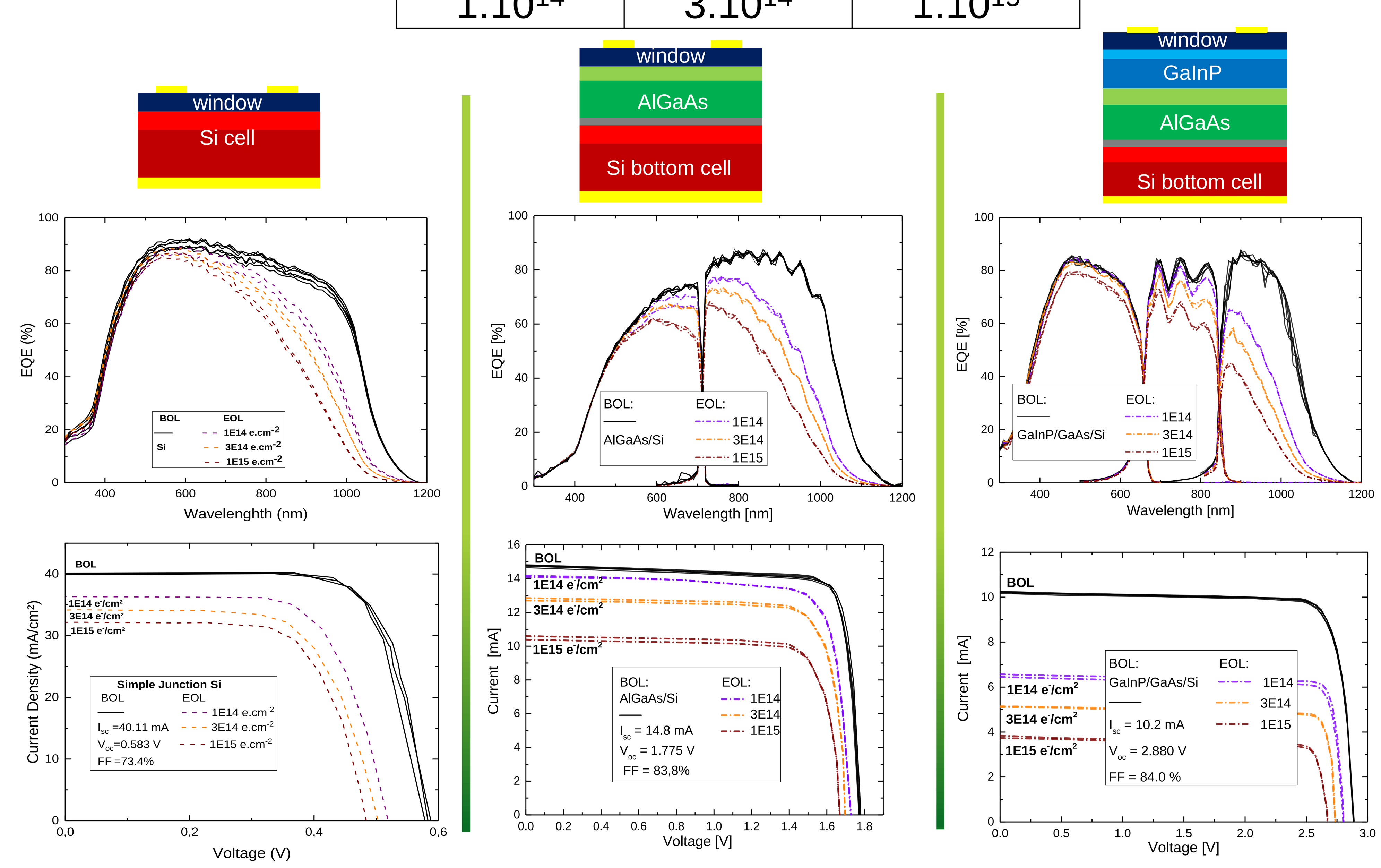
- Pro: independent optimization of Si and III-V cells
- Challenges: Surface preparation, III-V/Si recombination → emitter doping profile [6], passivated contact & light trapping [2]



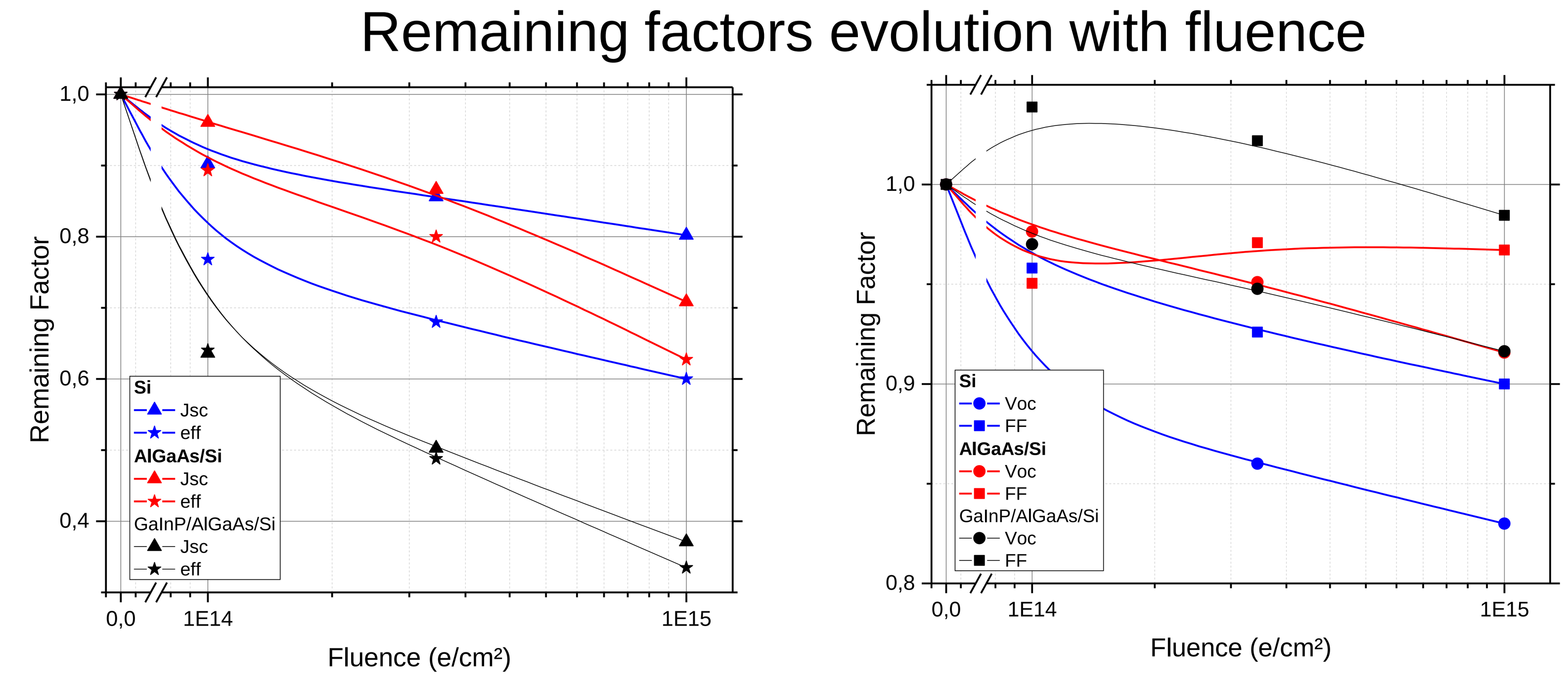
Irradiations of III-V/Si multi-junctions

- Irradiations at LSI: silicon, wafer bonded 2J AlGaAs/Si & 3J GaInP/GaAs/Si cells
- Room temperature electron irradiations, BOL/EOL ex-situ characterisations

1MeV electrons Fluence [e$^-$/cm^2]		
1.10^{14}	3.10^{14}	1.10^{15}



Remaining factors evolution with fluence



Conclusions & perspectives

- Higher degradation of open circuit voltage & Fill Factor on 1J than 2J or 3J
- Efficiency drop driven by strong degradation of Si bottom cell Jsc
- Near IR losses: 2J less damaged than 3J
- Optimization of BOL current matching and Si bottom cell design needed to improve radiation hardness
- Ongoing: study of temperature, intensity and protons irradiation effects

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