Optimization of Ion Beam Sputtered Ta_2O_5 Anti-Reflective Coatings for III-V Multi-Junction Solar Cells

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Introduction

- Low reflectance broadband antireflection coatings (ARC) are instrumental for full exploitation of the solar spectrum.
- Ion beam sputtering (IBS) produces reliable and repeatable optical coatings [1].
- IBS tantalum pentoxide (Ta_2O_5) is an attractive material for ARCs due to its relatively high refractive index and low absorbance at short wavelengths [2].
- Standard process for fabrication of Ta_2O_5 based ARC onto a MJSC reveals degradation of the device characteristics as shown in **Fig. 1.**
- Use of a thin IBS Al_2O_3 layer between the window layer and the high-index material works as a protective layer and preserves the solar cell functionality.

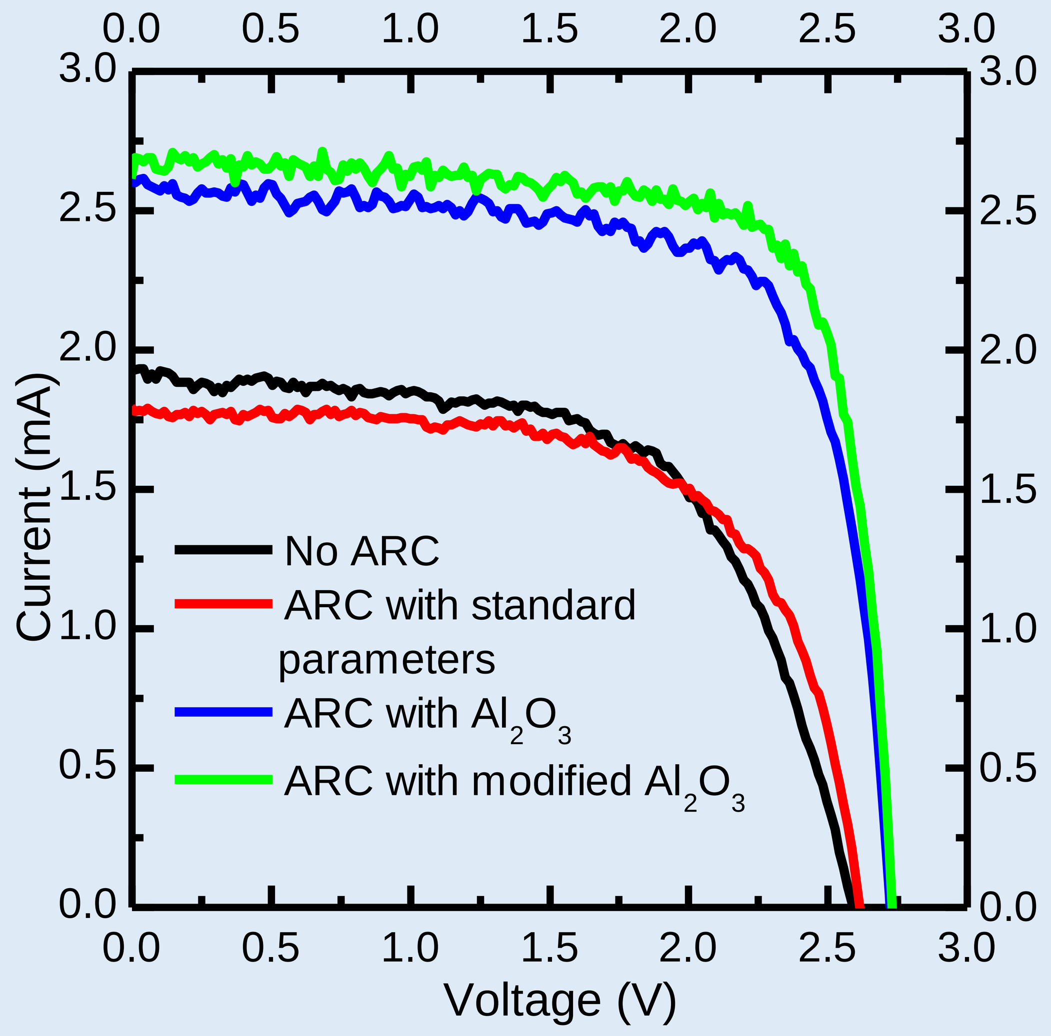
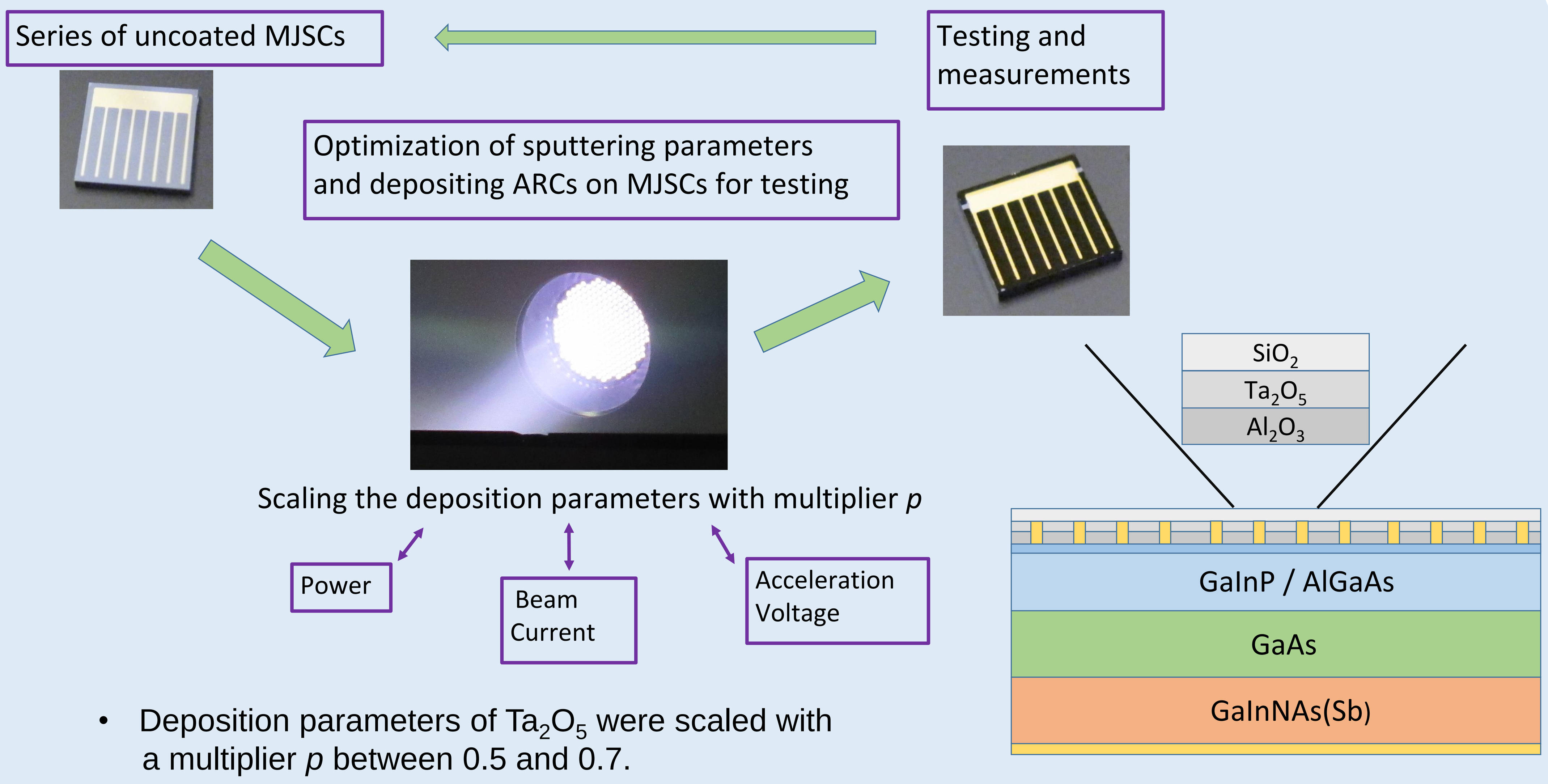


Figure 1. Current-voltage characteristics of GaInP/GaAs/GaInNAs(Sb) MJSCs at 1-sun AM1.5D having Ta_2O_5/SiO_2 ARC with and without protective Al_2O_3 layer.

Approach



- Deposition parameters of Ta_2O_5 were scaled with a multiplier *p* between 0.5 and 0.7.
- Thickness of the protective Al_2O_3 layer was varied from 0 to 10 nm.
- MJSCs having ARCs were characterized using photoluminescence (PL) mapping, spectrophotometry and current-voltage (*I-V*) measurements by a solar simulator.

Results

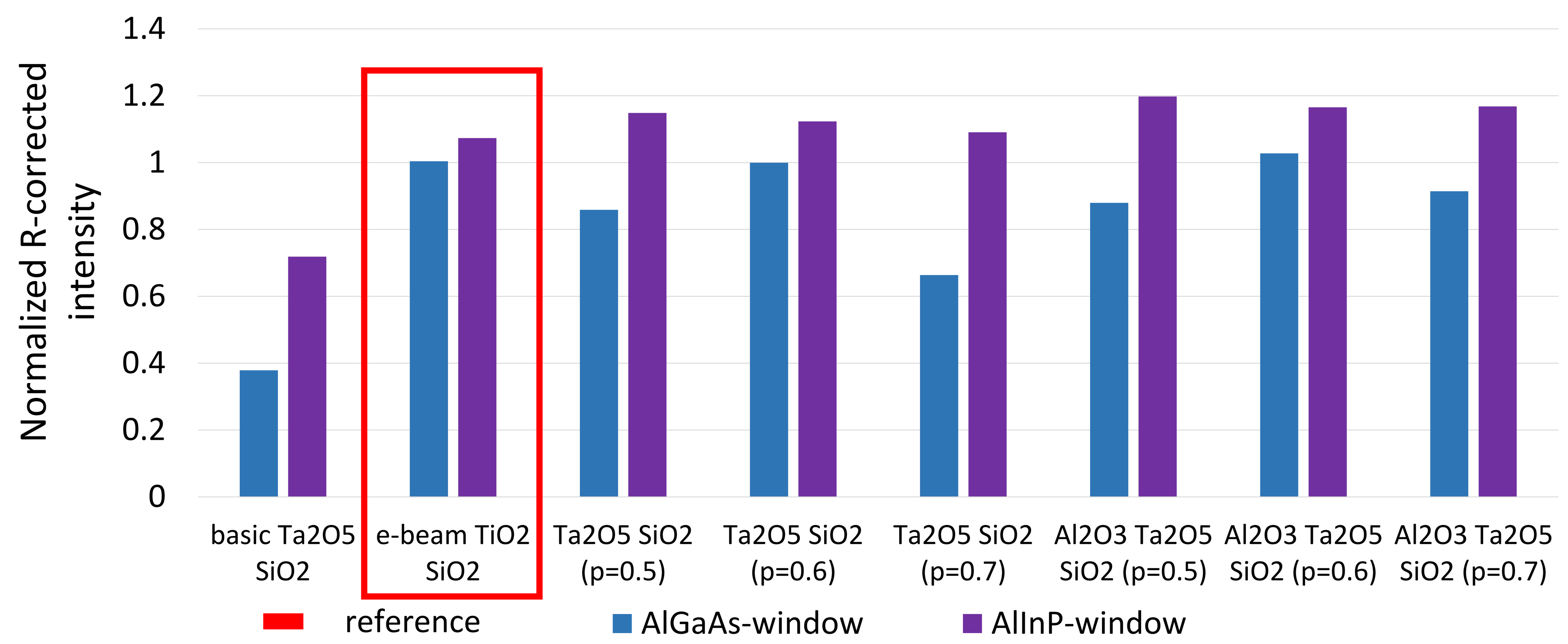


Figure 2. Reflectance-corrected PL intensities from the top cell surface (excitation at 532 nm) for MJSC structures with AlGaAs or AlInP window layer coated with parametrized Ta_2O_5 ARCs.

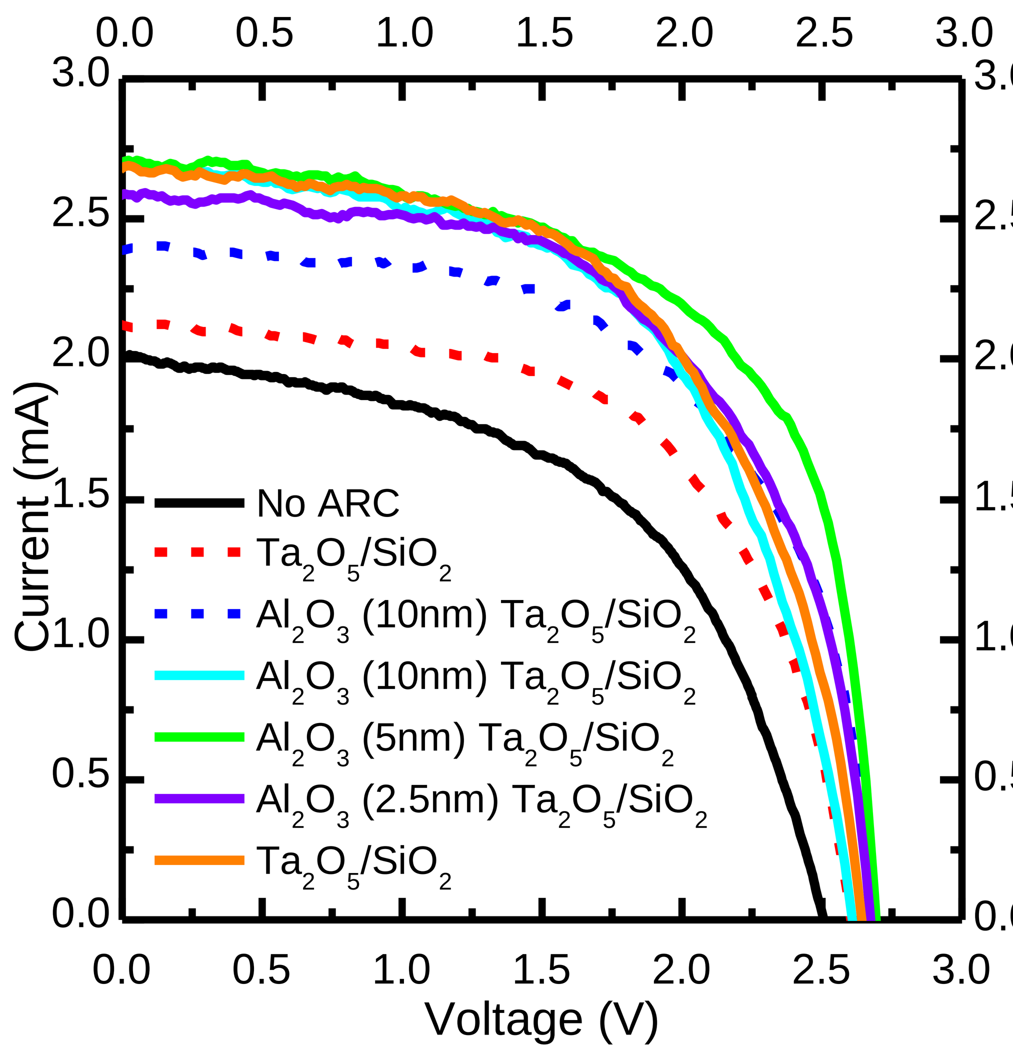


Figure 3. *I-V* characteristics of GaInP/GaAs/GaInNAs(Sb) MJSC at 1-sun AM1.5D with different ARCs. Dashed lines have standard Ta_2O_5 and solid lines have parametrized.

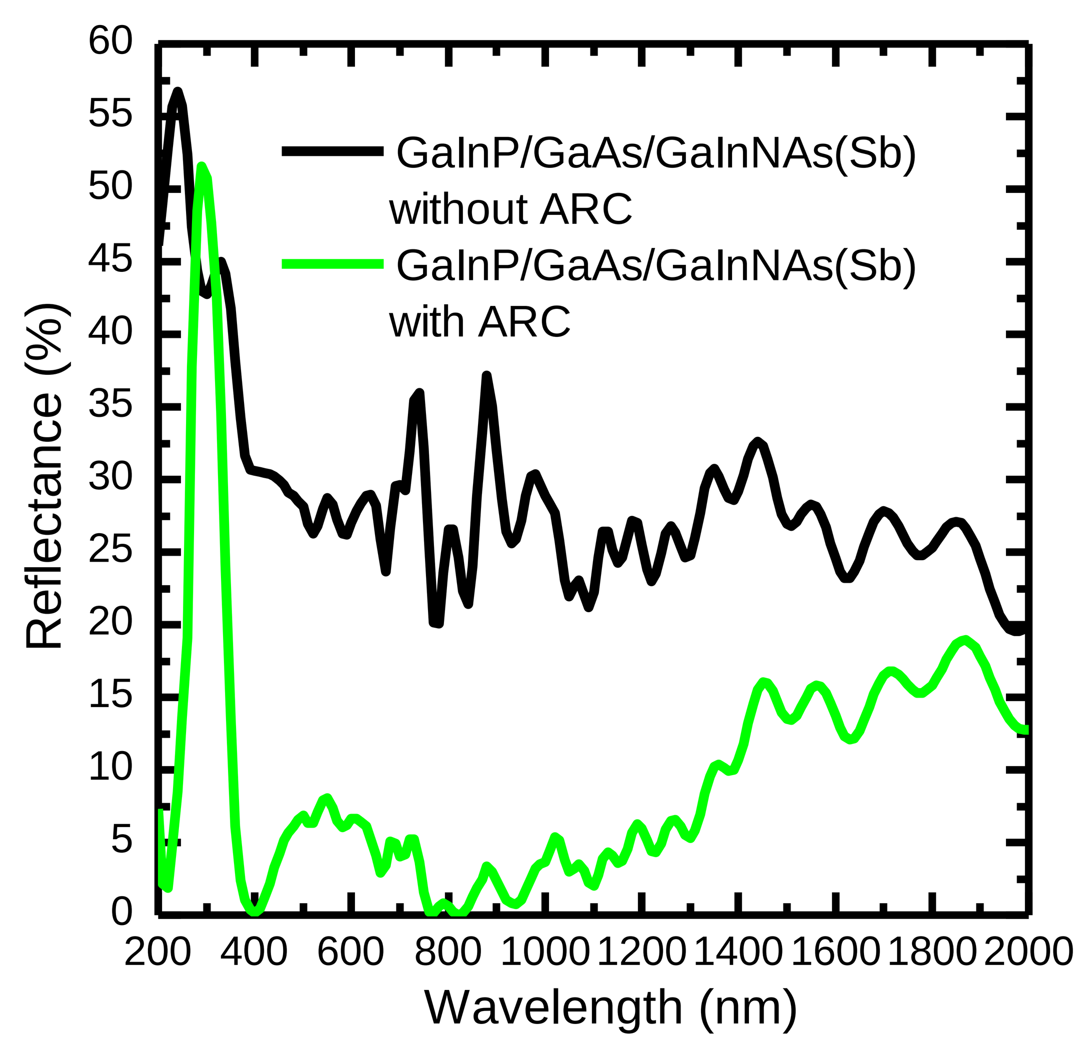


Figure 4. Examples of the reflectance spectra of a GaInP/GaAs/GaInNAs(Sb) MJSC with and without an ARC.

Conclusions

- Using IBS deposition for III-V MJSC ARCs requires tuning and optimization of the deposition parameters to prevent structural damage.
- By parametrization of IBS Ta_2O_5 we have avoided the negative effects caused by the deposition.
- A thin protective Al_2O_3 layer seems to be beneficial even after the optimization of Ta_2O_5.
- As we have successfully parametrized IBS deposition of both Al_2O_3 and Ta_2O_5 for III-V MJSCs it should also be possible for other materials, such as SiO_2 and TiO_2.

References
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[2] H. Demiryont, J.R. Sites, K. Geib, Effects of oxygen content on the optical properties of tantalum oxide films deposited by ion-beam sputtering, Appl. Opt. 24 (1985) 490. doi:10.1364/AO.24.000490

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