A 19.4%-efficient ultrathin GaAs Solar Cell with a Silver Nanostructured Back Mirror

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Enhancing the conversion efficiency and reducing the cost are two main issues for the development of photovoltaics. Single-crystal GaAs has been shown to achieve record efficiency, while the high material cost impedes its large-area application. Employing ultrathin absorbers (205 nm GaAs) and keeping high performance at the same time is our main objective.

III-V semiconductor stacks are grown by Metalorganic Vapor Phase Epitaxy (MOVPE) at the Fraunhofer Institute for Solar Energy Systems ISE. Fig. 1(a) shows a schematic solar cell structure and a cross-section SEM image. The nanopatterned silver back mirror is fabricated using scalable Nanoimprint Lithography. Its geometry is optimized using the Rigorous Coupled Wave Analysis (RCWA) method. The nanostructured back mirror induces multiple resonances in the long wavelength range and results in a dramatic increase in short-circuit current as compared to the same structure on a GaAs substrate (+8.9 mA/cm²) and to a flat mirror (J_{sc} +4.5 mA/cm²).

Experimentally, we demonstrate a record efficiency of 19.4% using only 205 nm GaAs absorber (Fig. 1(c)). We have also carried out a careful loss analysis. We detail the respective role of parasitic losses, resistive effects, edge and bulk recombination, and bandgap narrowing due to both photonic and doping effects. We also elucidate the role of the back reflector to make use of radiatively emitted photons and to obtain high V_{oc}. **Finally, we discuss a possible pathway to reach a realistic efficiency of >25% with 200nm-thick GaAs layers.**

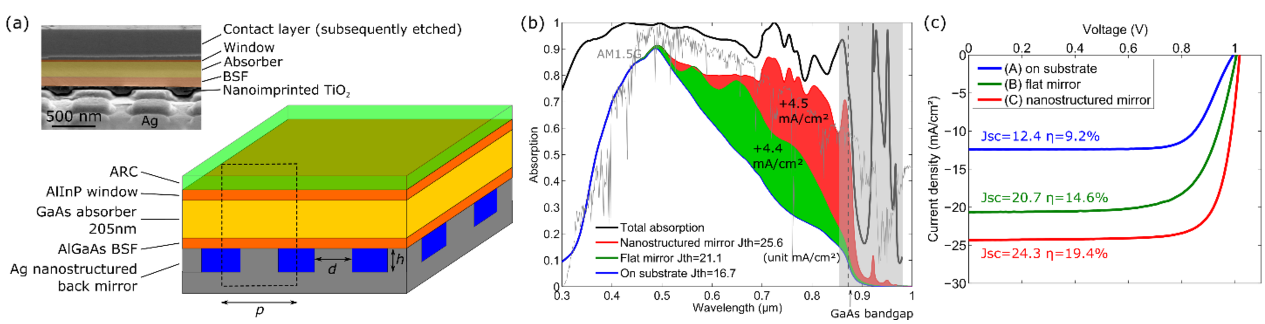

Figure 1: (a) Schematic illustration of solar cell structure and a cross-section SEM image of ultrathin absorber with nanostructured mirror. (b) Calculation of absorption in 205 nm GaAs with a GaAs substrate (no mirror), a flat mirror and nanostructured mirror. (c) Experimental IV curves under 1sun illumination.