Centre de Nanosciences et de Nanotechnologies

Soutenance de thèse

Lundi 20 janvier 2020

13h00
Centre de Nanosciences et de Nanotechnologies
10 boulevard Thomas Gobert
91120 Palaiseau
Amphithéâtre

Louis GOUILLART

" Development of ultrathin Cu(In,Ga)Se2–based solar cells with reflective back contacts"

Jury members :

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Abstract :
Reducing the absorber thickness of thin-film photovoltaic devices is a promising way to improve their industrial competitiveness, thanks to a lower material usage and an increased throughput. It can also increase their efficiency due to a shorter pathway for the separation of photogenerated charge carriers. Still, the efficiency of ultrathin Cu(In,Ga)Se2-based (CIGS) solar cells , which have an absorber thickness ≤500 nm that is approximately 5 times thinner than standard devices, is limited by two phenomena: the non-radiative recombination of charge carriers at the back contact and the incomplete absorption of the incident light. Several strategies were studied in order to mitigate those losses. First, the composition of ultrathin CIGS layers was optimized to create a grading of the semiconductor's conduction band minimum. The resulting electric field contributes to a better charge carrier separation and a lower back contact recombination rate. The incorporation of silver in the CIGS composition greatly improved the performances of ultrathin cells, leading to an efficiency of 14.9% (540 nm of ACIGS, without antireflection coating), close to the current record of 15.2% (490 nm of CIGS, with antireflection coating). Besides, the addition of an alumina passivation layer at the interface between CIGS (470 nm) and Mo was also investigated, and resulted in an improvement of the open-circuit voltage of 55 mV. Second, a novel architecture of reflective back contacts was developed. It consists of a silver mirror that is encapsulated with layers of transparent conductive oxides. Based on a transmission electron microscopy study, this back contact was shown to be compatible with the co-evaporation of CIGS at 500°C or more. Thanks to a high reflectivity and an ohmic contact with CIGS, it led to an increase of the efficiency from 12.5% to 13.5% and of the short-circuit current from 26.2 mA/cm² to 28.9 mA/cm² as compared to cells with a standard molybdenum back contact. This reflective back contact paves the way toward higher photovoltaic efficiencies as well as novel strategies for further light trapping.

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