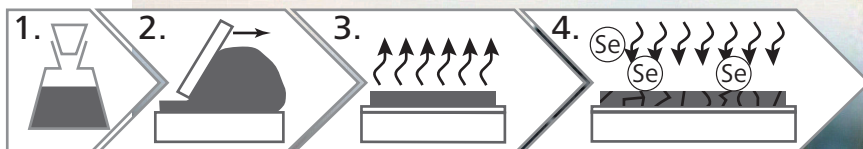


Low cost fabrication of $\text{Cu}(\text{In},\text{Ga})\text{Se}_2$ (CIGS) solar cells



Invention

The invention consists of a simple non-vacuum deposition method for $\text{Cu}(\text{In},\text{Ga})\text{Se}_2$ (CIGS) solar cell absorber layers. The technology is based on non-toxic and non-hazardous solutions for safe processing of thin film solar cells. The formulated solutions can be applied onto glass or flexible substrates with deposition techniques such as coating or printing, which can be used at industrial scale offering large area and low cost manufacturing of solar modules.

Background

CIGS solar cells have demonstrated highest conversion efficiencies amongst all thin film technologies of up to 20.3% [1]. Current deposition methods for high efficiency cells, are based on vacuum methods, i.e. sputtering or co-evaporation, which enable controlled deposition, yet require expensive vacuum equipment with limited throughput. In this respect, non-vacuum methods offer several advantages due to their inherent large area uniformity, higher throughputs, improved material utilization from 40-70% (evaporation/sputtering) to >90%, and low investments. Previous studies have shown the potential of non-vacuum methods by yielding up to 14.5% efficiency solar cells from nanoparticle inks [2]. Nanoparticle inks require sophisticated production and stabilization, as well as often involve explosive and toxic gases for their conversion. True solution approaches yielded up to 13.6% efficiency when using toxic hydrazine solvent [3]. Up to 6.7% efficient solar cells were possible using non-toxic solvents with cellulose organic binder that resulted in a residual carbon layer between absorber and back contact [4].

Advantages

Our innovative process involves binder-free solutions of metal salts in alcohol solvents. The method is reproducible, without a deposition step in highvacuum, which resolves the previously reported problems so that it:

- excludes the need of pre-fabricated nanoparticles or organometallic molecules;
- does not require addition of organic binder materials to adjust the solution rheology;
- omits the need of additional reducing steps, and thus, reduces the number of process steps;
- omits the use of highly toxic and explosive materials;
- offers the possibility to form a carbon-rich layer functioning as an electrical back contact, which renders the need to prepare a metal back contact.

Using this technology, CIGS solar cells with efficiencies of up to 7.7% have been achieved. Further efficiency improvements and process scalability to large areas are feasible.

Applications

The technology is suitable to realize printed CIGS solar cell on glass and flexible substrates. Printed CIGS solar cells and panels can reach efficiencies competitive with crystalline silicon panels in the near future. The non-vacuum printing technology minimizes the use of expensive, high vacuum manufacturing equipment, thus reducing the total capital expenditures (CAPEX) while maintaining high production throughput and raw material utilization of more than 90%.

Ownership

Empa, Swiss Federal Laboratories for Materials Testing and Research, Ueberlandstrasse 129, CH-8600 Dübendorf; Patent pending

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Keywords

Photovoltaics, solar cells, CIGS, non-vacuum deposition, solution deposition, printing

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