

NEW APPROACH FOR AN INDUSTRIAL LOW-TEMPERATURE ROLL-TO-ROLL CI(G)S DEPOSITION PROCESS

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We present a new approach for industrial roll-to-roll deposition of Cu(InGa)Se₂ (CIGS) thin films on polyimide foil for use as absorber layers in thin film solar cells.

In our opinion one major advantage of this deposition technique is an easy low-cost scalability with high lateral homogeneity. Lateral thermal radiation from the front side may be an additional advantage, particularly for the low temperature process.

In a first step the molybdenum back contact is deposited on a 30 cm-wide polyimide substrate (Upilex), i.e. a multilayer consisting of titanium, molybdenum and Mo:Na, in order to introduce sodium into the CI(G)S material. Subsequently the absorber is deposited in a separate roll-to-roll machine, which combines sputtering and evaporation techniques in one process chamber. The metals (Cu and In) are deposited onto graphite bars by magnetron sputtering. Therefore an argon pressure of $\sim 5 \cdot 10^{-3}$ mbar is present in the chamber. The graphite bars serve as evaporators and after the sputter deposition, the metals are well-directed re-evaporated from the bars onto the substrate. Each evaporator consists of several graphite bars, arranged in a cylindrical form. Via stepwise rotation and application of a current to the single bar the evaporating metals create a periodical flux profile. The entire metal evaporation takes place under selenium atmosphere. For this purpose, the selenium vapor is introduced via thermal evaporation using infusion cells. The maximum substrate temperature is 460°C. Figure 1 depicts a top view draft of the described CI(G)S-process at Sunplugged GmbH (SunP). The cross-sectional view with described parts marked is illustrated. The deposition process is a modified 3-stage-process. Basic process concepts were developed at the University Milano-Bicocca [1].

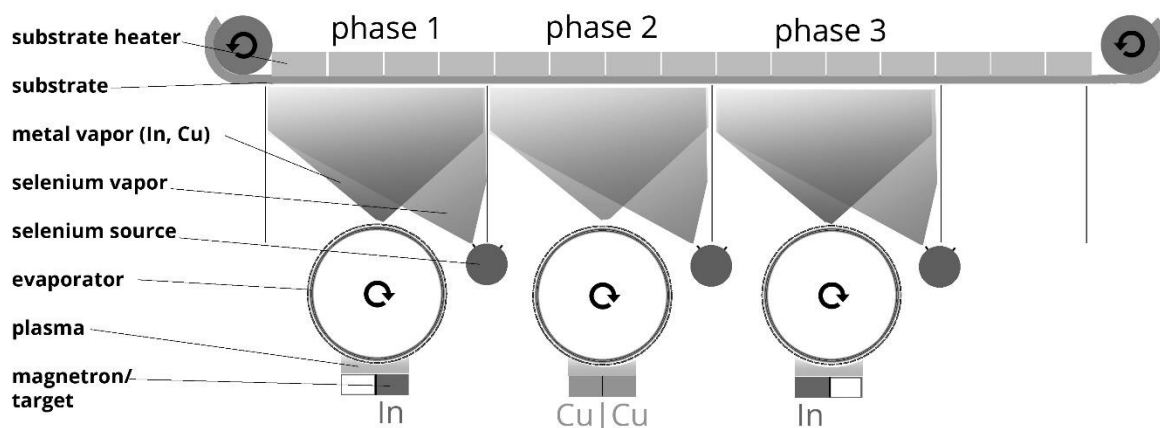


Figure 1: Topview of Sunplugged's CI(G)S deposition process. Metal components are sputtered on graphite bars and subsequently evaporated and deposited on the polyimide substrate. Selenium is introduced by temperature-controlled infusion cells.

Both, the back contact molybdenum deposition and the deposition of the CI(G)S absorber are performed on a roll-to-roll pilot production line at Sunplugged GmbH in Austria. For device fabrication the deposition of the buffer layer, the transparent front contact and a contact grid are deposited on single samples in batch-type processes at the Helmholtz-Zentrum Berlin für Materialien und Energie. The highest total area, lab scale cell efficiencies achieved till date without Gallium are >10% (1.0 cm²). Besides an introduction to the process, loss analysis of current status and a road map to reach state of the art efficiencies are part of the proceeding.