Summary

$Cu(In,Ga)Se_2$ (CIGS) and perovskite based thin film solar cells are currently the most attractive of all thin film PV approaches. Goal of the SOLAMO project (L7516013) is to advance both technologies so that they can be put together in a tandem structure someday.

CIGS

In the meantime, the CIGS vacuum deposition reactor, which was already ordered within the previous reporting period, has been delivered, built up and accepted. The plant fully complies with the specifications or even exceeds the requirements. Shortly after the commissioning already rather good absorbers have been deposited. A CIGS low temperature deposition at nominal 380°C via a so-called 3-stage process has led to a solar cell efficiency of up to 14.5 % on polyimide film. On glass substrate even 17.2 % has been reached at low temperatures (420°C).

The highest efficiency so far is 17.7 % which has been achieved on glass at a substrate temperature of 500°C. However, the efficiency is not directly correlated with the substrate temperature. It is rather a complex interaction of the amount of sodium and potassium doping, the interdiffusion of Cu, In, Ga and Se and the implanted Ga gradient over the CIGS thickness.

First experiments to increase the deposition rates have been performed at low temperature (400°C) by using polyimide substrates. We have shown in this approach that the evaporation rate of copper can be doubled without affecting the achieved efficiency.

Perovskite

Our activities have been continued to investigate perovskite based solar cells in standard and inverted structure both in opaque and semitransparent configuration. The deposition of the standard setup has been improved and the undesired hysteresis has been reduced by using PCBM and Al_2O_3 nanoparticles. With the inverted approach even nearly hysteresis-free and reproducible efficiencies of about 15 % have been achieved.

To reduce costs we have substituted the evaporated silver back contact by a sputtered aluminium layer. Cell efficiencies higher than 10 % have been achieved by this means.

A semitransparent indium tin oxide (ITO) front contact has been tested both in standard and inverted configuration in order to realise semitransparent perovskite devices. Efficiencies > 13 % have been demonstrated with both structures. In parallel, 70 % light transmission in the wavelength region > 775 nm have been saved to be used in a tandem setup with a CIGS or silicon based subcell.

First glass-glass encapsulation tests have shown, that even after a storage time of 9 months in the dark an efficiency of > 12 % (initial eff.: 14.9 %) can be reached. This corresponds to a degradation rate of 18 %.

First experiments have been performed to fabricate lead-free perovskite solar cells. Experiments with bismuth-containing absorbers showed a diode characteristic, but nearly no photocurrent. Thus, efficiencies of only 0,02 % have been measured. Main reason for this is the insufficient layer coverage. To overcome this, other solvents combined with mixed cation approaches will be investigated.

As a first step towards upscaling of the technology, mini-modules with four monolithically interconnected cells have been fabricated onto substrates of 3x3 cm^2. The efficiency has been 9.4 % with an active area of 3.8 cm^2.