INNOLAS LASER APPLICATION NOTE

Selective Laser Structuring of Organic Solar Cells with picolo sub-ns laser

Organic Photovoltaics (OPV) is a promising technology to provide a further cost reduction for the generation of electricity, especially for customized form factors. The production of large-area semi-transparent organic solar cells on flexible substrates in a roll-to-roll process is the next generation technology for reducing manufacturing costs. To increase voltage and reduce current for the power extraction single OPV cells are serial monolithic interconnected to modules. This is achieved with three selective laser structuring processes: P1 (pattern 1) - Separation and galvanic isolation of the back contact, P2 - ablation of the absorber layer for front contact opening and finally P3 - separation and galvanic isolation of the front contact (see Fig. 1).

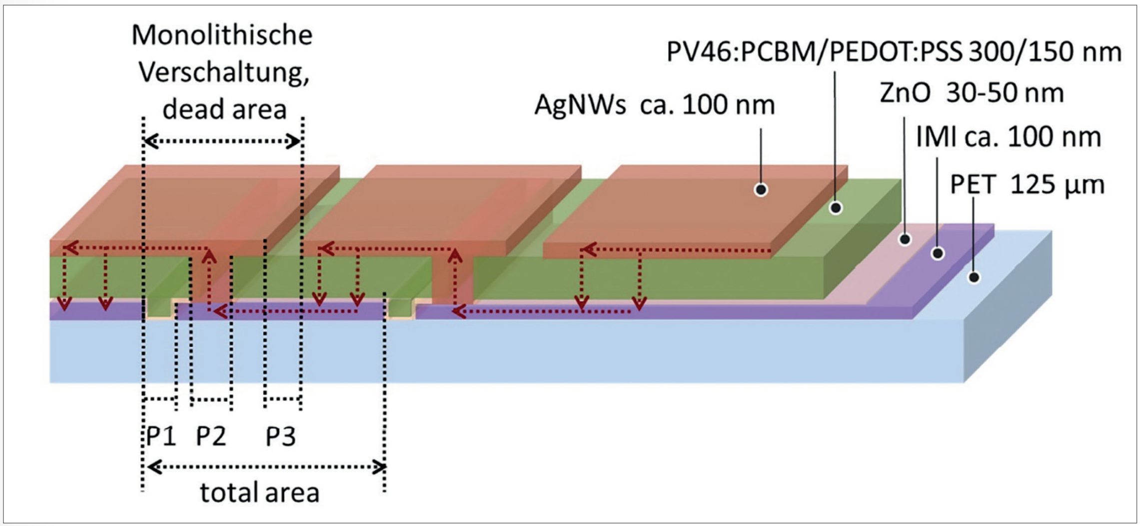

Figure 1: Typical structure of an organic solar cell with monolithic interconnection: P1 separates galvanic the back contact (IMI), P2 opens the absorber layer (PV46:PCBM/PEDOT:PSS) to the back contact, P3 separates the front contact (AgNWs). Red arrows indicate the flow of current in the solar cell.

In the Bavarian research project ORGANOLAS, InnoLas and the research partners LHM (Lasercenter Hochschule Munich) and ZAE (Bayerisches Zentrum für Angewandte Energieforschung) were aiming to develop processes for the selective sub-ns laser structuring of OPV cells to achieve the complete serial interconnect of a solar module.

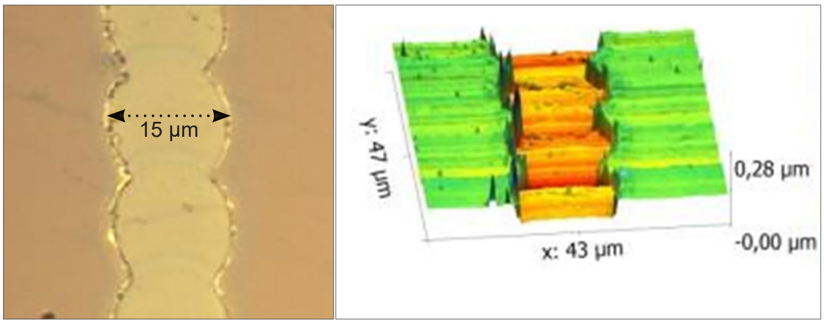

Figure 2: Light (left) and confocal (right) microscopy image of a typical P1 line in a 80 nm thick IMI film structured with a picolo laser with 800 ps pulse duration at a wavelength of 1064 nm, via back side or front side ablation with an overlap of 60% at a fluence of 0.2 – 0.5 J/cm². After wiping the P1 line exhibits clean morphology leading to a high isolation resistance.

Best monolithic interconnects have been created to date with selective femtosecond laser structuring with pulse durations of about 500 fs, which is not very cost effective, because of the high prices of fs laser sources. The compact and cost-effective sub-ns lasers picolo from InnoLas Laser offers a pulse duration of 800 ps, leading to a precision in the sub-µm range, precise enough for a selective laser structuring of OPV cells.

Figure 2 shows microscopy images of a typical P1 line in a 80 nm thick IMI film (sandwich of Indium-Tin-Oxide (ITO) – metal – ITO) structured with a picolo laser at 800 ps pulse duration and a wavelength of 1064 nm. The P1 line exhibits a clean and precise morphology with a width of 15 µm and a depth of 80 nm leading to a high isolation resistance. In ORGANOLAS also processes for P2 and P3 lines were developed for the picolo sub-ns laser. Finally, a complete OPV solar module was structured with the picolo (see Figure 3). The module exhibits a solar efficiency of 2,1%, which is which is close to the 2,3% of an fs structured module. This proves that the picolo laser is a viable tool for selective structuring of thin films.

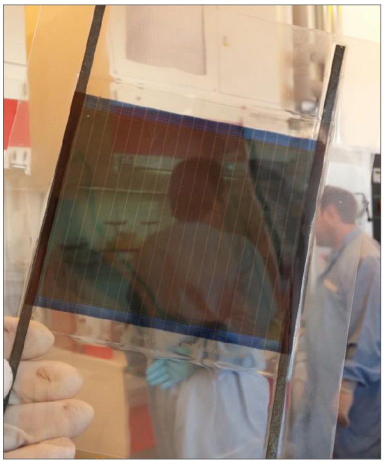

Figure 3: Complete OPV solar module selectively structured with a picolo laser from InnoLas Laser. The module displays an efficiency comparable to module structured with a femtosecond laser.

Prof. Heinz P. Huber from LHM states that with the picolo laser we have reached a monolithic interconnection that is almost as good as with a fs laser, but much more cost-effective. The picolo is a reliable tool, air-cooled and easy-to-use for research or for an industrial use in a production environment. At the Lasercenter we have also been very successfully using the picolo since 2011 for time-resolved pump-probe-microscopy due to its short sub-ns pulse duration of about 800 ps. In our time resolved experiment the picolo has been continuously generating research results, that we have published in a lot of papers.

Other applications for the picolo are: Laser Ultrasonics, MALDI, Atmospheric Research, Aereal Mapping, PLD, OPCPA, Particle Physics, EUV Generation, Nonlinear Applications, Laser Cleaning, LIL, Marking, Laser Ablation and finally as demonstrated here Selective Laser Structuring of thin films.

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