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Plasma-assisted nanosecond laser structuring of photovoltaic cover glasses

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Photovoltaic cover glasses make a considerable contribution to the overall energy conversion efficiency of photovoltaic devices. For improving the illumination of the actual converter, antireflective coatings or direct patterning of cover glass surfaces can be applied. In order to achieve light trapping by multiple reflections and a selective guiding of incoming sunlight, prismatic microstructures, moth eye surfaces or sub-micrometre diffraction gratings turned out to be suitable patterns. Several approaches such as lithography, compression moulding or direct laser structuring are in hand for the realisation of such structures. Here, the laser represents the most versatile tool since principally, no forms or masks are required. However, the use of laser sources is limited to selected laser wavelengths due to the transmission characteristics of glassy materials.

Against this background, we present a novel atmospheric-pressure plasma-assisted laser ablation method which allows overcoming this limitation. In a first step, photovoltaic cover glasses are plasma treated at atmospheric pressure applying a hydrogenous working gas. This treatment results in a modification of the chemical composition of a near-surface glass layer, namely a reduction of glass-forming oxides and an implantation of hydrogen. As a result, the absorption is notably increased, allowing both the use of cost- and energy-efficient nanosecond laser sources for micro structuring and an improvement of the laser machining quality due to a better coupling of incoming laser irradiation in the second step. For instance, the form error of the ablated spots was decreased by 45% without any mentionable change in the ablation rate and process speed, respectively.

In this contribution, the underlying mechanisms, main results and possible applications of this hybrid method are presented.

Keywords: photovoltaic cover glass, laser structuring, energy-efficient manufacturing