“NIR laser-assisted delamination: a promising step towards high value PV module recycling”

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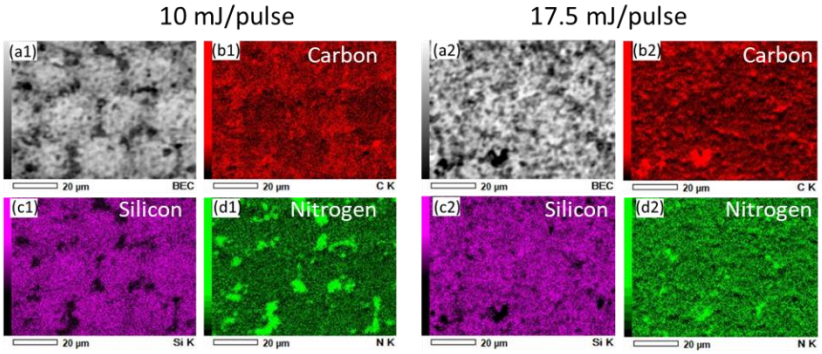
A crucial step for recycling solar panels is the delamination of the front and back sheets (glass or polymer), to access the cells and their metallization where most of the value for recycling can be harnessed. Although new designs might be implemented in the near future to facilitate this step, this does not address the issue of the large amounts of silicon solar panels, not designed for recycling, which will be decommissioned in the coming years. Therefore, specific solutions should be investigated this installed base of panels. In this contribution, we present a method, based on a near infrared laser, which debonds the encapsulant from the silicon wafers in a fast and energy-efficient manner, by pulverising a thin superficial layer of silicon, along with its SiNx anti-reflective coating. We first determined the ablation threshold for the silicon/SiNx stack, then optimised the laser settings to uniformly ablate the silicon surface while minimizing the carbon contamination due to cross-heating to the EVA (Figure 1). After a subsequent mechanical separation step, the glass and encapsulant can be cleanly removed (see example in Figure 2). A nanosecond laser treatment was also tested on a full module and yielded very promising results. Some specific challenges of the laser-based method and its potential for industrial deployment will also be discussed.



Element\ E_{pulse}(mJ)	10	12.5	15	17.5	20	22.5	25	27.5
C	11.1	10.9	13.2	16.7	20.0	21.7	24.0	40.5
N	3.1	0.7	0.0	0.0	0.0	0.0	0.0	0.0
O	2.1	2.1	2.4	2.6	2.9	3.7	2.9	5.8
Si	83.8	86.3	84.3	80.7	76.4	73.9	72.3	52.9
Al	0.0	0.0	0.0	0.0	0.6	0.7	0.8	0.8
C/Si	0.13	0.13	0.16	0.21	0.26	0.29	0.33	0.77

Figure 1: EDS mapping and quantification (see table) of a wafer surface after a laser treatment at 10mJ (a1-d1) and 17.5mJ pulse energy and mechanical separation.

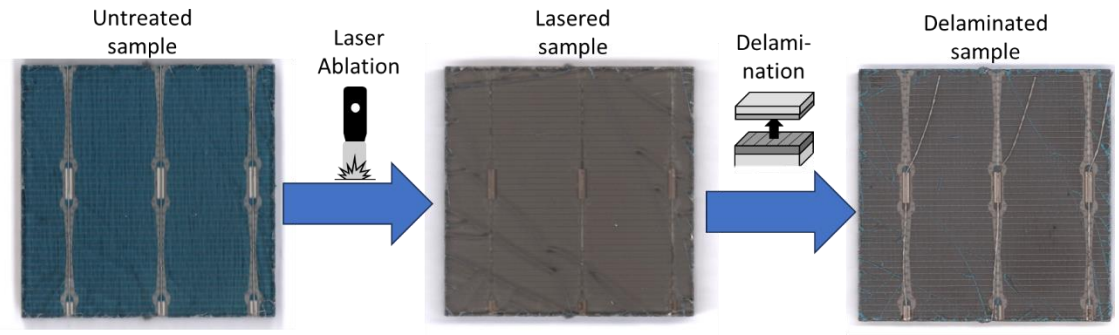


*Figure 2: photographs of a sample untreated (left), lasered (middle) and after mechanical separation of the glass and encapsulant (*right*)*