How thin film modules die: extraction method and post-mortem lab analysis on defects found in commercial CIGS modules

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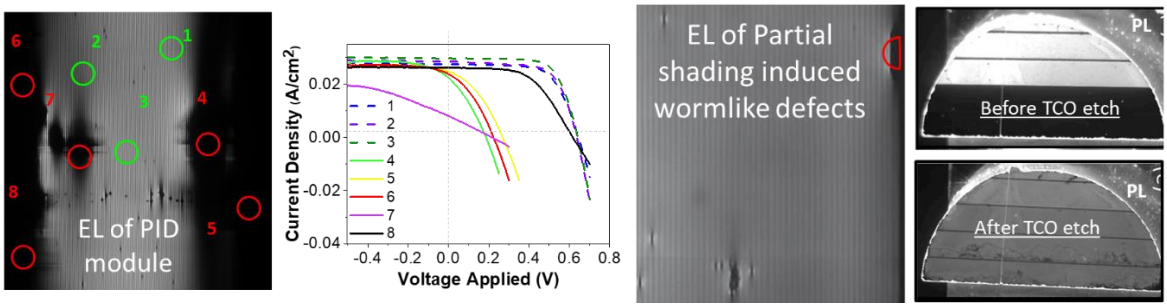
Thin film photovoltaics production has been growing steadily over the past few years, with an estimated 7 GWp produced in 2019 [1], of which CdTe and CIGS were the largest. These technologies, more recently commercialised than crystalline silicon, are less mature and their failures and degradation modes are therefore less well understood. $Cu(In,Ga)(S,Se)_2$, for example, can be grown with or without sulphur and via different fabrication processes [2]. The exact cell stack (e.g. buffer layer, TCO, encapsulant) also varies from one manufacturer to the next. All this means that different failure modes can potentially occur that will have an effect on the device performance and/or lifetime. So far, most studies on defects in CIGS are carried out at the cell level, i.e. on devices grown in the lab environment and/or on defects artificially induced in modules [3] [4, 5]. However, the defects found in such devices can differ significantly from "naturally" arising defects in modules operating in the field. In the present work, we demonstrate a method to extract samples from commercial, fully laminated modules and unpackage them for analysis with conventional lab-scale characterisation tools. The extraction method ("coring") and the unpackaging stage do not damage the active layers of the sample, so that the devices can later be contacted into mini-modules or cells and undergo current-voltage (I-V), external quantum efficiency (EQE), Photo- and electro-luminescence (PL/EL), Illuminated or Dark Lock-In Thermography (ILIT/DLIT) etc. To illustrate the potential of the method developed, we show some results obtained on potential-induced degradation (PID) and partial shading-induced wormlike defects in commercial CIGS modules.



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