Defect Detection in Photovoltaic Modules using Electroluminescence Imaging

**Defects of c-Si modules**

**Cracks and breakages:**
Cracks and breakages in the semiconductor material are responsible for the majority of power loss cases in crystalline silicon cells. The EL and power measurements of 4 different c-Si modules showed a direct correlation between the power drop and the breakage size. Further experiments identified mechanical stress and temperature change as the major causes behind the proliferation of cracks and breakages.

**Defective edge isolation:**
EL-measurements could also be used for identifying areas of defective edge isolation. These areas feature low luminescence values and appear dark on the EL-image.

**Contact grid interruptions:**
Contact grid interruptions are a further common defect in c-Si modules. In the electroluminescence image, these defects are easily detectable in the form of dark areas surrounding the interrupted finger and reaching to the cell edges.

**Defects of thin film modules**

**Shunts:**
EL showed a good suitability for detecting shunts in thin film modules. These common defects, especially in CIGS-based modules have a very particular EL brightness pattern: a localized darkness within a single cell having a particularly dark (in some cases a particularly bright) center and a symmetric appearance along the cell. It could be shown through the comparison of EL-measurements that light soaking remarkably affects the size of the shunts and thus their impact on the module performance. A rise of up to 8% in the output power could be noticed after 24h of light soaking treatment.

**Laser scribing failures:**
EL-measurements also allowed the detection of failures induced by the laser scribing process. Damages in the metallic rear contact or the TCO front contact are particularly easy to detect and appear as dark areas surrounding the laser scribe lines and covering various large parts of the adjacent cells. Stress situations such as elevated temperatures, excess humidity or high voltages accelerate the failure process.

**TCO-corrosion:**
Additionally, the measurement setup allowed the detection of TCO-corrosion zones, induced by high negative voltages at high temperatures and humidity levels. Since the moisture penetration occurs at the module edges, the dark areas are concentrated in the outer zone of the module. A linear dependence between the corroded area (darkness in the EL image) and the power drop could be shown.

**Summary**

In this work, EL imaging was shown to represent a powerful quality assessment tool for both crystalline and thin film solar modules. When properly adjusted and configured, the system is able of accurately detecting numerous failures and ageing effects in very short times.