High resolution LBIC characterization of defects in mc-Si solar cells

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Background

- Photovoltaic industry is dominated by solar cells based on mc-Si
- Structural defects (grain boundaries, impurities, dislocations) act as recombination centers and decrease the efficiency of the cell
- Characterization techniques like ELi and PLi allow a fast study of the defects at the expense of the spatial resolution

Objective

Measuring the electrical activity of defects in commercial mc-Si solar cells at micrometric spatial resolution using the Light-Beam Induced Current (LBIC) technique combined with a ELi - PLi system

Methods

We have developed a homemade LBIC system enabling high spatial resolution

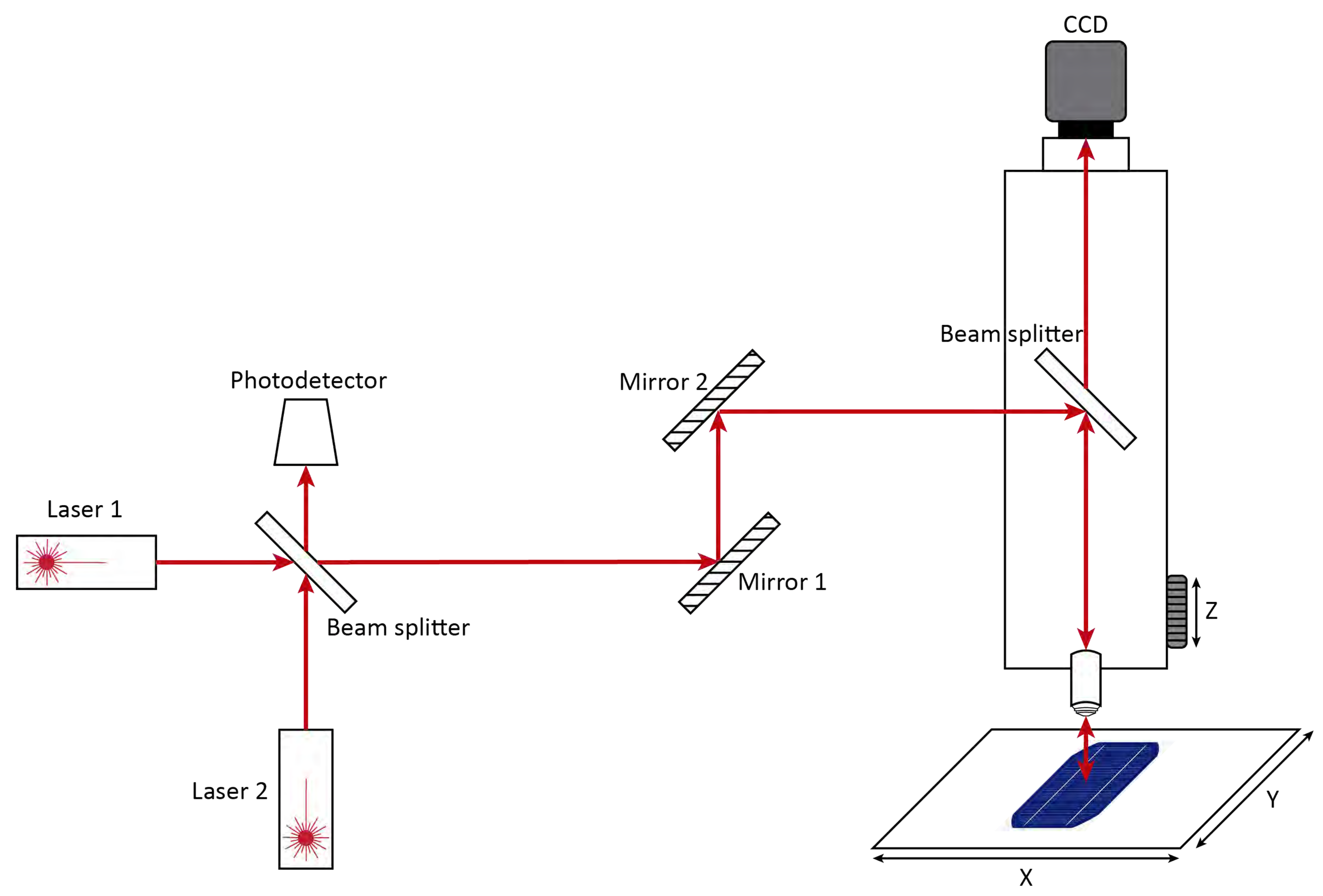
LBIC system

- Four excitation wavelengths (639, 830, 853 and 975 nm) for different penetration depths
- Laser power control via software to ensure low level injection
- Different objectives (20x, 50x, 100x) enable studies up to 1 µm of spatial resolution
- A CCD camera is used to focus the laser and measure the light reflected by the cell
- High precision X-Y-Z motorized stage

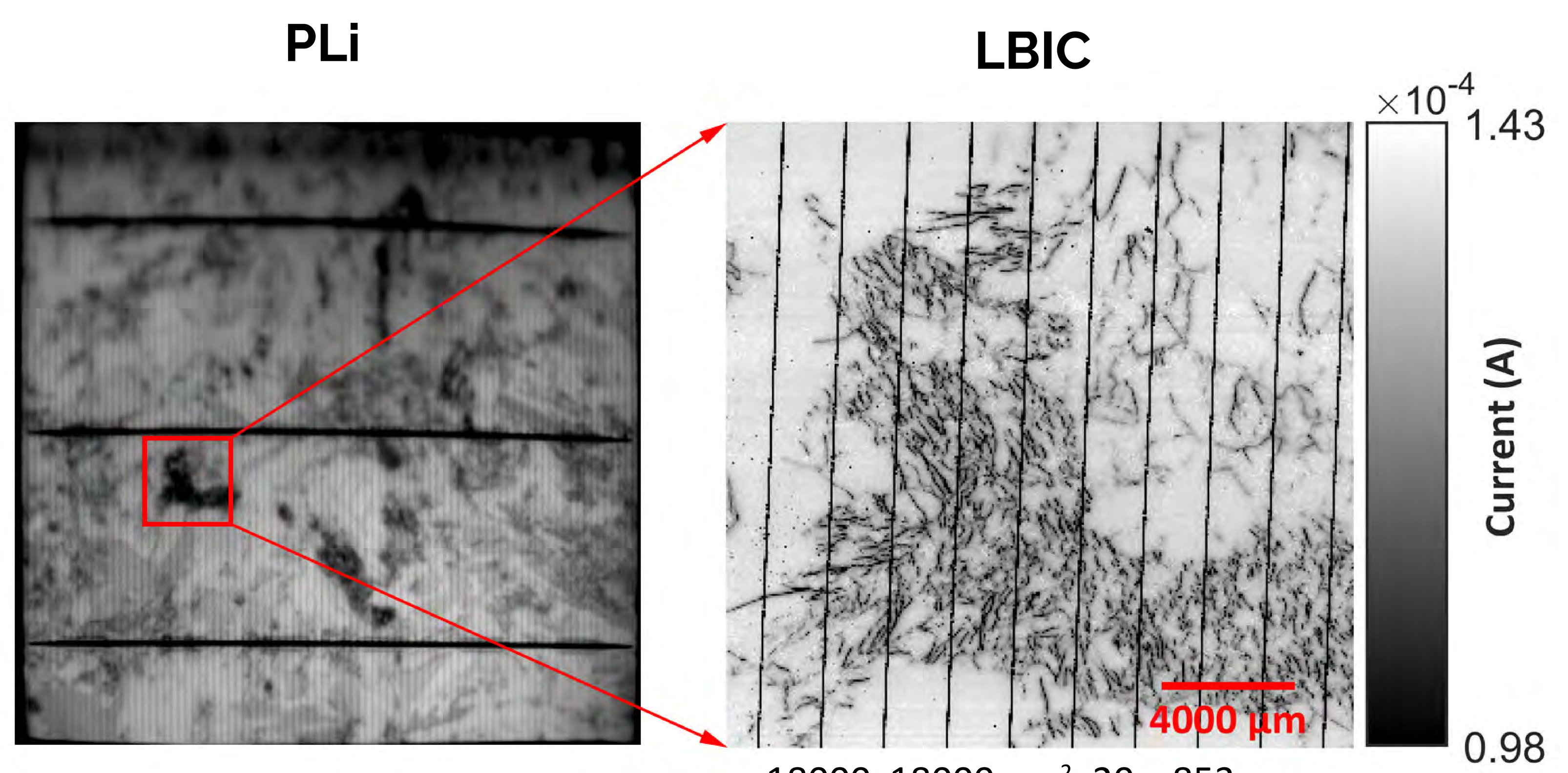
Control software

- Hardware control and data acquisition
- Autofocus algorithm

LabVIEW



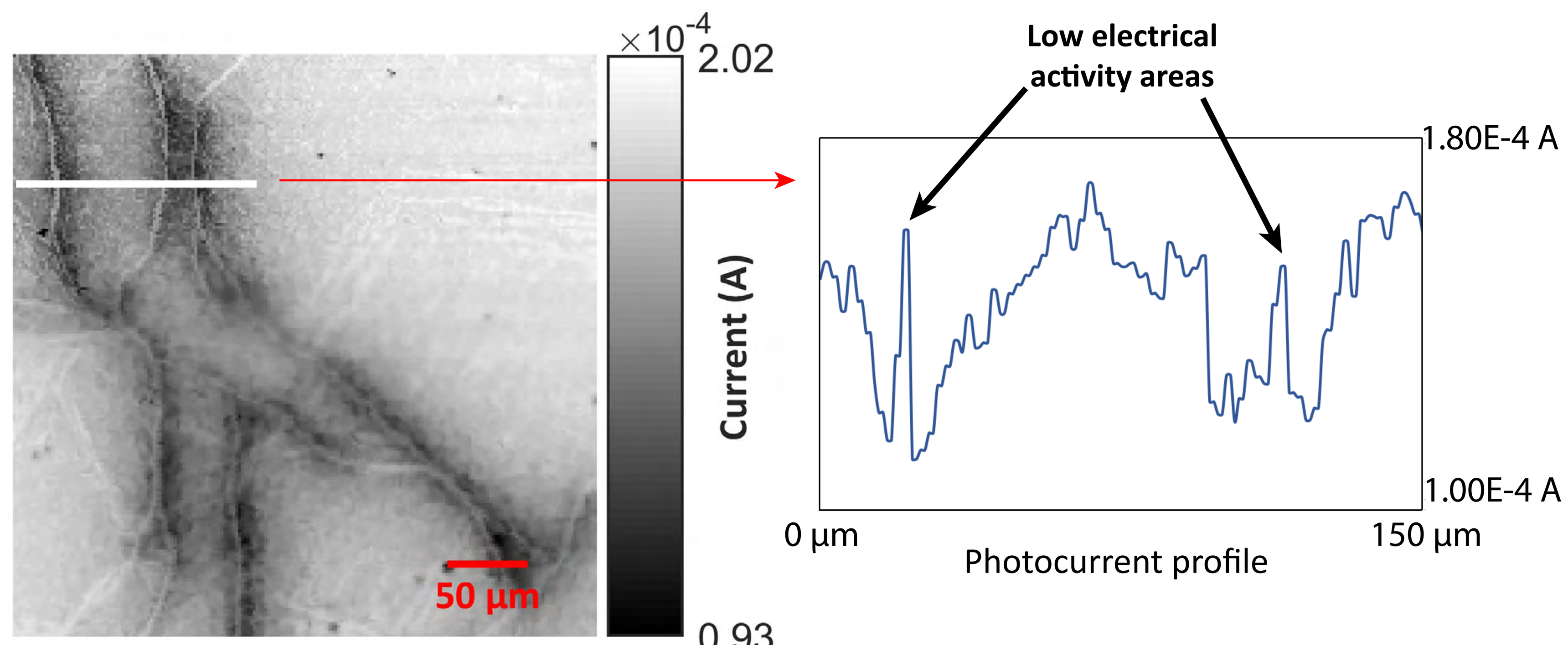
Results and discussion



18000x18000 µm², 20x, 853 nm

- PLi showed better contrast than ELi
- Good correlation between PLi and LBIC measurements
- Detailed information about the structure of the defects in the LBIC map and better signal to noise ratio
- LBIC took long acquisition time whereas PLi took few seconds

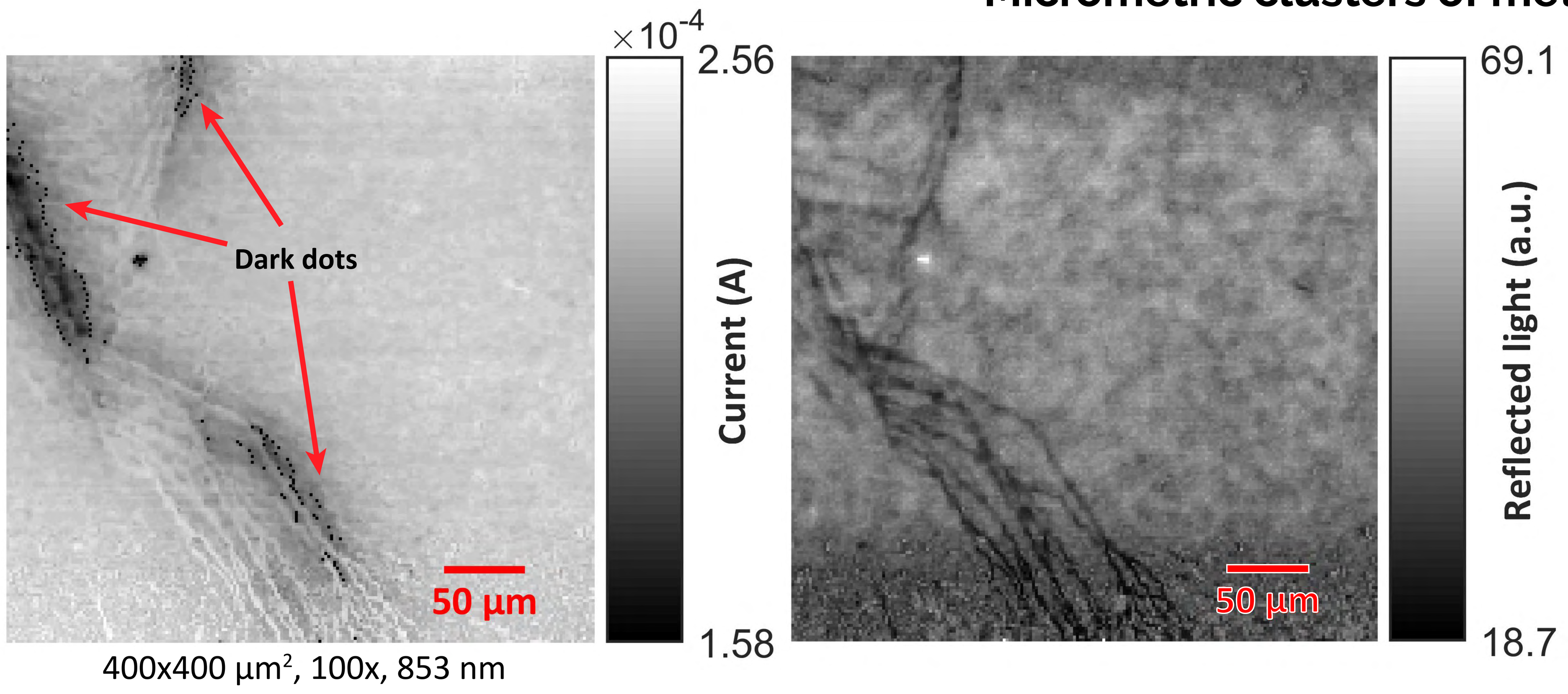
Low electrical activity along the core of the defects



400x400 µm², 100x, 853 nm

- High resolution LBIC maps reveal intragrain defects presenting low electrical activity along the core of the defects and high capture rates around them
- The high current at the core can arise from impurity depletion or a higher effective excitation due to lower reflectivity

Micrometric clusters of metallic impurities



400x400 µm², 100x, 853 nm

- Some areas present micrometric size dark dots at both sides of the core of the defect, with a pronounced drop in the photocurrent
- The reflected light map of the solar cell reveals information about the core of the defects but not about the dots
- This can be explained as an accumulation of metallic impurities which give rise to clusters with high electrical activity

Conclusions

→ ELi - PLi combined with LBIC enable measures from a fast full-wafer observation to a micrometric scale characterization of the defects in mc-Si solar cells
→ A detailed identification of electrical activity areas along the core of the defects can be obtained with high resolution LBIC measurements
→ Reflected light mapping allows to establish a correlation between LBIC maps and surface features

DRIP XVII Valladolid, Spain 8 - 12 October 2017

Acknowledgements Spanish MINECO project, ref. ENE2014-56069-C4-4-R and Junta de Castilla y León project, ref. CP16/58.

Gobierno de España · Ministerio de Economía y Competitividad · Junta de Castilla y León