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Current Density and Resistive Loss Patterns in Defect-free and Defective Organic Solar Cells by Finite Element Modelling

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Abstract

Finite element models of different laterally extended polymer solar cells were applied in order to investigate current pathways and dissipative losses in organic solar cells, especially in the presence of local shunt defects. The models are of purely resistive nature, as this is sufficient to describe the effects under consideration. Remarkable agreement was found between the experimental and calculated thermography results in defect-free solar cells. All this provides a further step towards a quantitative description of the losses in defect-free and defective solar cells.

1. Extended Abstract

We constructed finite element models of different laterally extended polymer solar cells in order to investigate current pathways and dissipative losses in organic solar cells, especially in the presence of local shunt defects. The models are of purely resistive nature, as this is sufficient to describe the effects under consideration.

The model calculations yield the spatial distribution of the current densities, potentials and the according resistive losses. In defect-free solar cells, the current density and loss patterns cover the entire area of the transparent electrode (ITO). In the close vicinity of the shunt defects, the current density exhibits large maxima leading to respective maxima in the power loss. On the other hand, non-negligible currents are spread out covering the entire area of the devices, running along the electric potential gradient.

The current density mainly contributes to the resistive loss density of the device. The loss, in turn, is a consequence of the delicate interplay between the individual layer properties, namely the resistivities and layer thicknesses in combination, also in the presence of locally concentrated defects. Furthermore, the dissipative loss patterns are the origin of respective heat patterns, which are visible in dark lock-in thermography imaging experiments. Thermographic imaging is excellently suitable to represent the aforementioned losses under operating conditions [1-3]. Remarkable agreement was found between the experimental and calculated thermography results in defect-free solar cells. (cf. Figs. 1,2)

All this provides a further step towards a quantitative description of the losses in defect-free and defective solar cells.

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2. Figures and tables

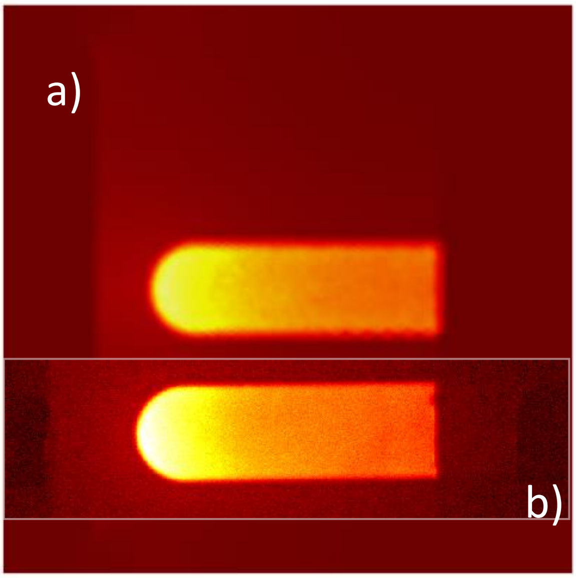

Fig. 1. *(a) Heat pattern emphasizing mainly the active area and the associated electrode. This part of the heating occurs mainly due to the resistive loss in the active area. There also exists a heated forward section, mainly between the active Al back contact tip and the Al front contact. (b): DLIT image taken from PCDTBT for comparison.*

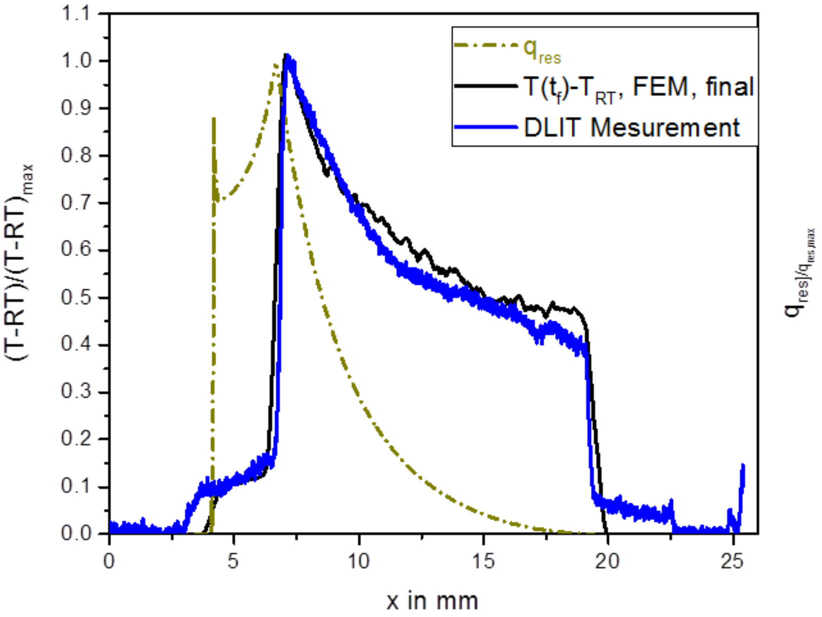

Fig. 2. *The surface temperature T-RT normalized by (T-RT)max in a line at the back side surface of the glass substrate. The dashed plot displays qres with its non-vanishing portion in the ITO bridge. Also shown is the normalised line section of the DLIT measurement, with striking agreement of the behavior in the vicinity of the active area and the ITO bridge alike.*