Crosstalk Between Pixels of Organic Photo-Voltaic Devices

Introduction

For various technological reasons, LEDs and as well as photo-voltaic devices frequently use PEDOT:PSS on top of ITO contacts as a hole injecting or hole collecting layer, respectively. However, due to the presence of this layer, a direct parasitic current path opens up between the ITO contacts of neighboring pixels.

Next to its influence on the optical properties of the layered device, the presence of the PEDOT:PSS layer between pixels may modify the potential profile in the active organic layer underneath and may therefore influence the lateral charge separation process in the illuminated device, causing optical induced electric crosstalk.

In this *Simulation Standard* we demonstrate the principal capabilities needed to simulate crosstalk between neighboring illuminated and dark pixels.

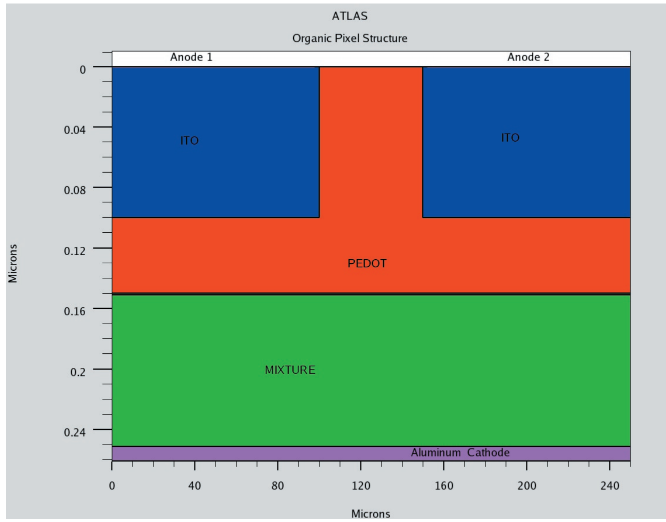

Figure 1. Device Structure – Neighboring Pixel. Note the very different scales along the horizontal and vertical directions.

Device and Models

The simulated structure of two neighboring pixels is shown in Figure 1. On top of an Aluminum layer, acting as common cathode, a blend of organic materials is deposited. This is followed by a 50 nm thick PEDOT layer of $\rho = 5 \times 10^4$ Ωcm resistivity. The ITO electrodes for the two 100 μm wide pixels have a thickness of 100 μm and are separated by a 50 μm wide gap filled with also PEDOT. The resistivity of ITO was taken to be $\rho = 160$ Ωcm. The optical simulations were performed for monochromatic light at a wavelength of 550 nm. The optical properties for the layer materials used are taken from tabulated values stored in a user defined file. The corresponding data a shown in Figure 2.

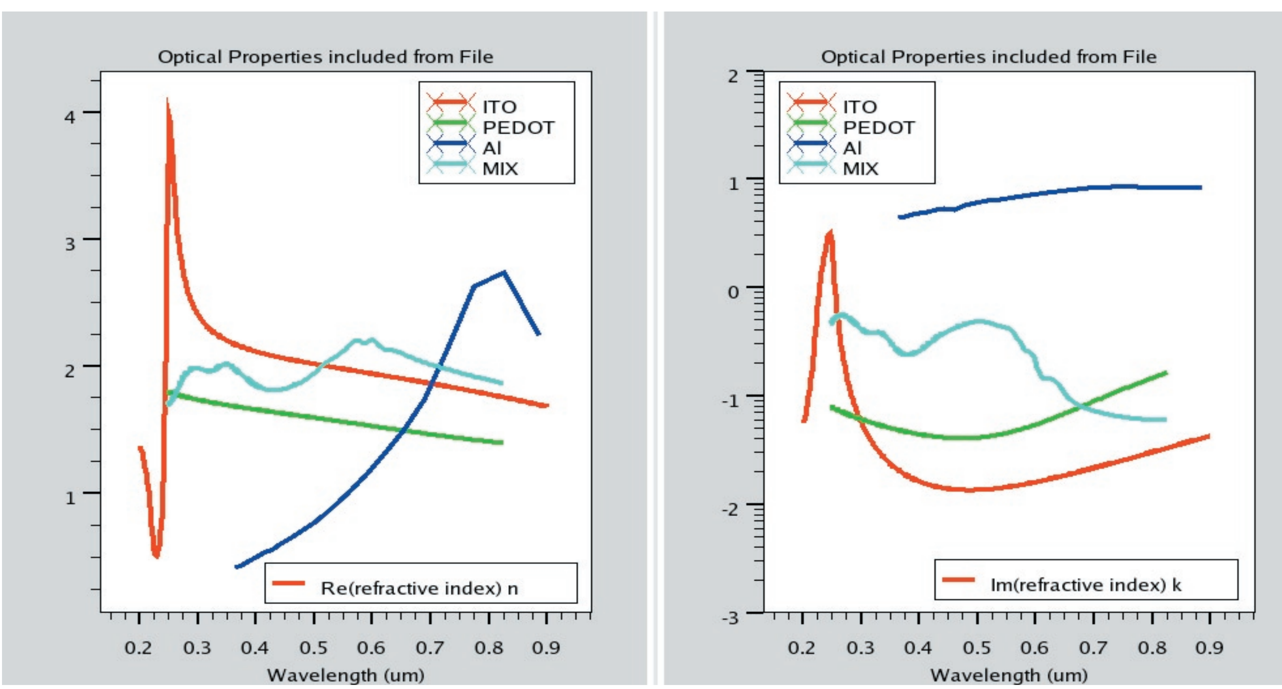

Figure 2. Optical Properties of layer materials used in the simulation.

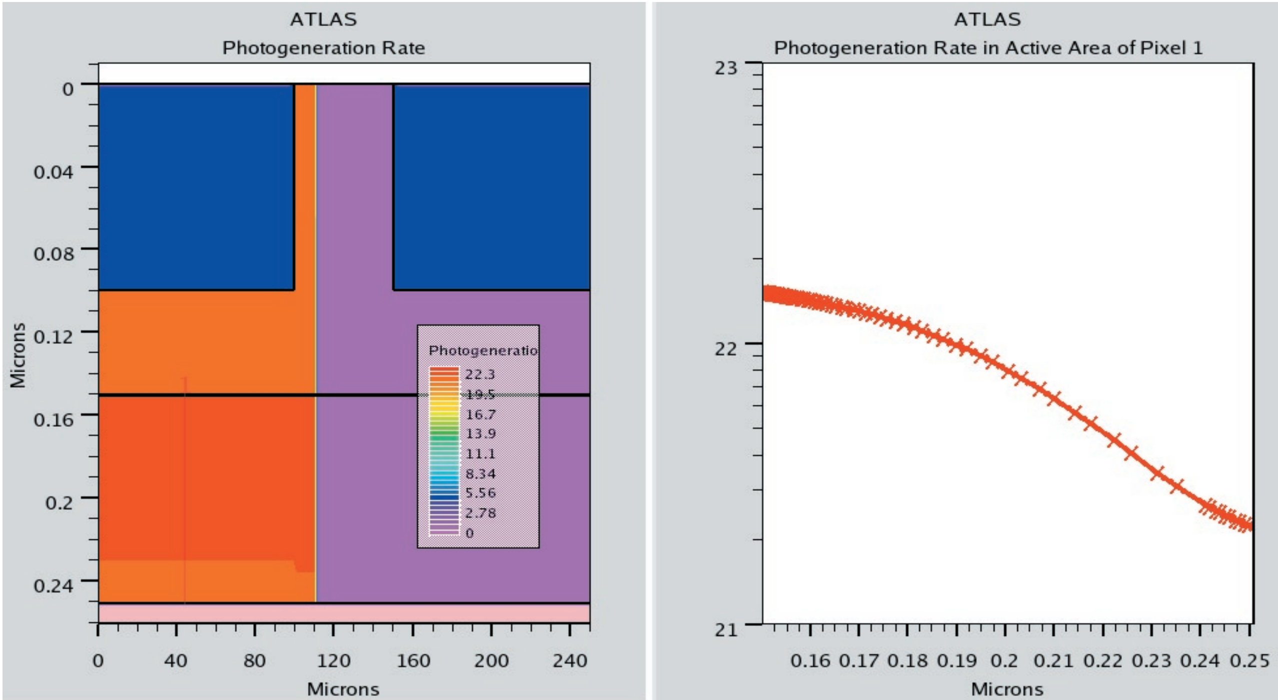

Figure 3. Illuminated Device: Photogeneration Rate along cutline in the illuminated Pixel.

Due to the fact, that layer thicknesses in such devices are typically in the same order of magnitude as the wavelength of the absorbed light, interference effects can be important. Such effects can be fully taken into account, using the implemented transfer matrix algorithm, utilizing the almost one-dimensional geometries of such devices. Although not exemplified here in detail, we note, that this can be important to optimize the absorption profile in such devices. In the present example, the resulting absorption profile is shown in Figure 3. This results in IV characteristics for the neighboring pixels as shown in Figure 4. The characteristics of the left pixel is shown under dark and illumination conditions in the left part of the Figure. In the right graph, the current through the

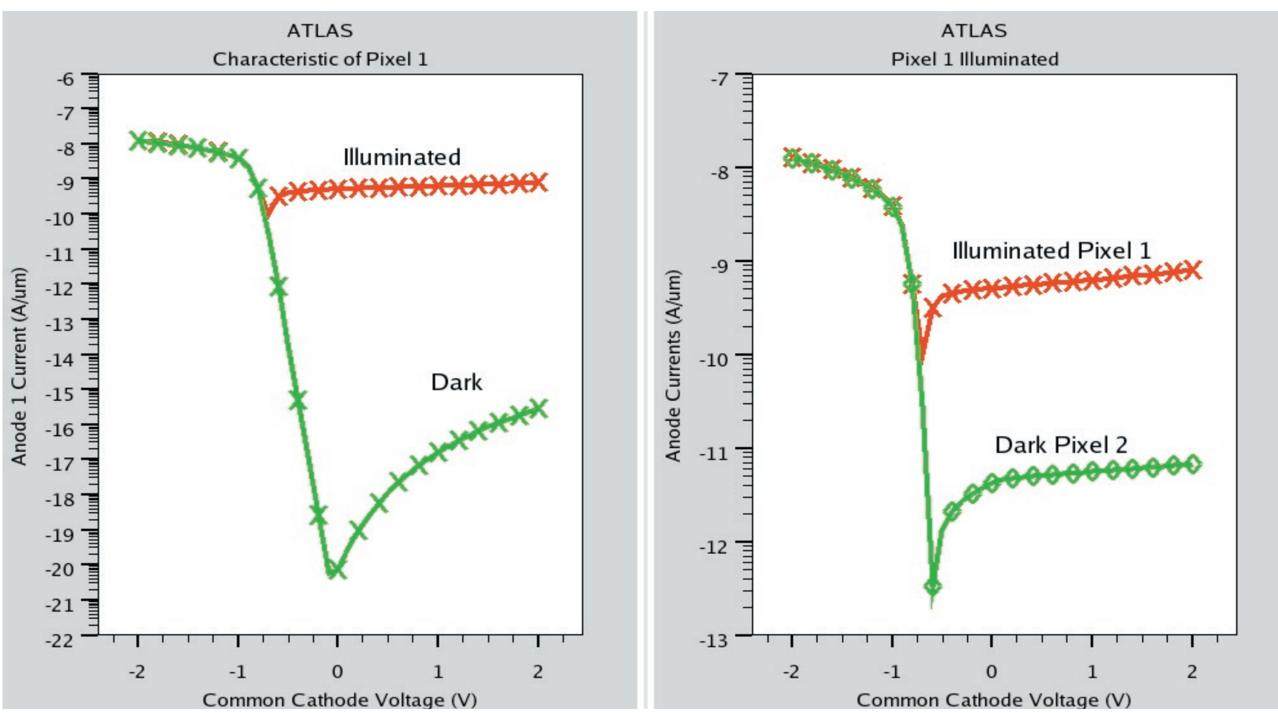

Figure 4. IV Characteristics of Pixels. Only Pixel 1 is illuminated homogeneously with light of 550 nm wavelength.

illuminated pixel 1 is compared with the current through the neighboring dark pixel. Although no bias is applied between the anodes of the two pixels, a considerably higher reverse current is observed in the dark pixel if the neighboring pixel is illuminated. This indicates, that the observed increase in current of the dark pixel originates in a laterally spread photo-voltaic effect causing internally different biases at the Schottky contact between the active and the PEDOT layer. By applying a bias between the anodes of the two pixels, a similar effect together with direct conduction along the PEDOT layer can be observed. The corresponding IV curves are shown in Figure 5. The magnitude for the current along the PEDOT layer is in the present example typically about 95% of the observed current between the pixels. This was checked by introducing a small dielectric barrier to separate the PEDOT layer between the two pixels.

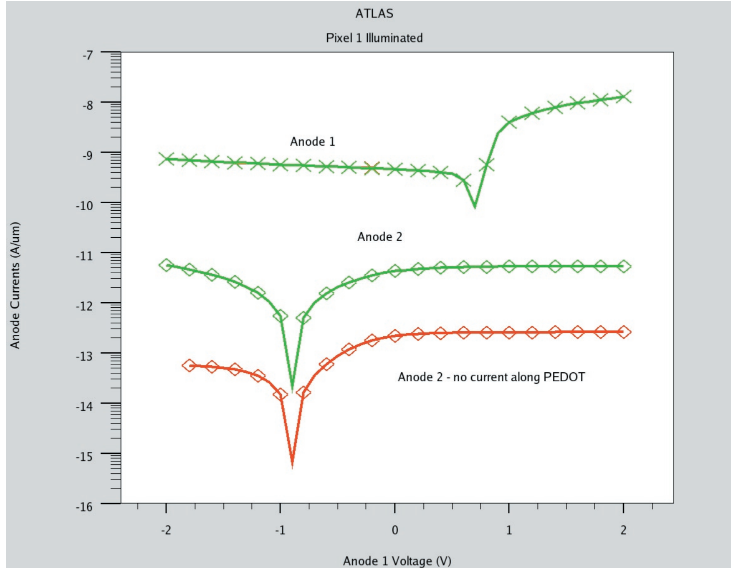

Figure 5. Anode currents for the two neighboring pixels. Pixel 1 is illuminated. The common cathode is grounded. The red curve is calculated for a device with a thin dielectric layer to separate the two pixels electrically along the PEDOT layer.

Conclusion

Employing the models implemented in ***ATLAS***, we investigated the electrical crosstalk of neighboring pixels with and without illumination. The transfer matrix method was used to calculate the light intensity profile within the given layered structure, taking into account the realistic complex refractive index of the materials. The results indicate, that the crosstalk between the given pixels is not only direct via the shorting PEDOT layer between the anodes of the pixels, but also due to the electric crosstalk along the highly conductive common bulk layer.