Microscopy of LEDs and phosphors in practical exercises for students

Application Note

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1. Introduction

We mostly use the Neo-5.5 sCMOS camera for practical courses at our university, where students have to characterize LEDs and LED phosphors. Hence, we subdivide this user report into the installation and handling of the NEO-5.5 as well as Andor´s SOLIS software. Subsequently we present some student-generated images of cold-white and warm-white LEDs photographed during their practical exercises in their course "SSL".

2. Installation

The installation of the NEO-5.5 according to the manual is straightforward. The assembly of the supplied PCIe Camera Link Card for data transfer is a simple plug-in operation.

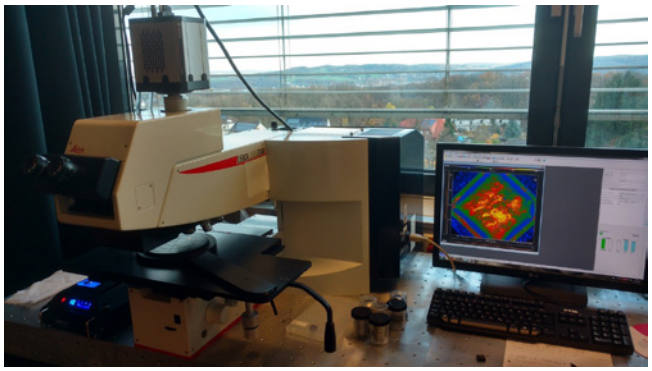

Fig. 1: Photography of the microscopy setup with the NEO-5.5 camera and the Andor SOLIS software.

The installation of the Andor SOLIS software works flawlessly on Windows 7. Total installation time, including PC setup, software installation and hooking up the recirculatorsystem for the water cooling is a matter of approximately one hour.

Figure 1 shows the NEO-5.5 mounted on a Leica INM300 microscope. A warm-white LED is being investigated by using the Andor SOLIS software.

2.1 SOLIS Software

The SOLIS software has proven to be reliable and is easily operated even by students due to its intuitive user interface. Multiple optional features beyond the basic version are available, but have not been tested in our setup. SOLIS constantly monitors camera parameters and reports relevant operating parameters, like chip-temperature, data-rate and scaling bar for the intensity.

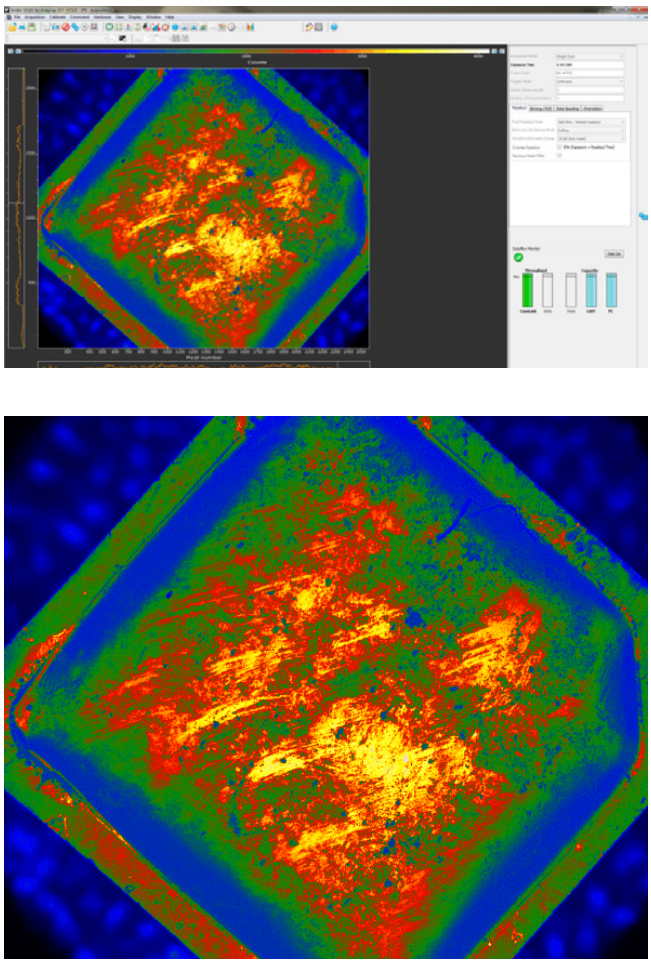

Fig. 2: Screenshot of the user interface of the Andor SOLIS for Imaging software (above) and saved as tif-image (below).

The scaling legend is not saved by default when exporting the acquired images to .tiff format. The possibility of exporting the images into formats like ascii and MP4 can be beneficial, but was not sufficiently used by us yet.

2.2 ImageJ & MicroManager

A big advantage is the compatibility of the Andor camera to ImageJ and MicroManager, respectively. This allows our students to utilize the same software for data evaluation at home as during data acquisition in the lab. Exemplarily the option to produce extended focus images from Z-stacks is used to analyze bond-wire positioning in different LED-types. MicroManager as well as the Andor SOLIS software allow displaying the images in false colors or black and white (see figure 3 and figure 4).

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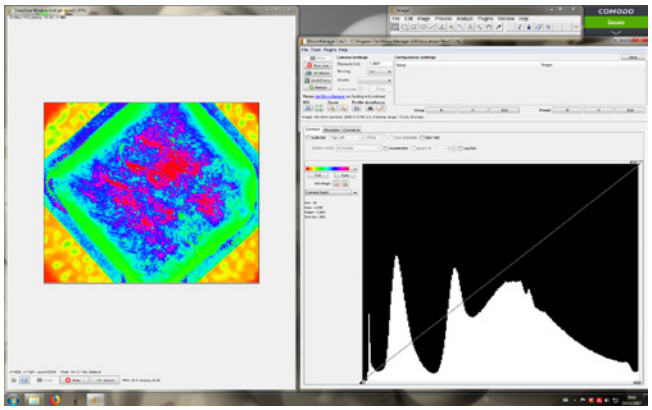

Fig. 3: Warm-white LED in MicroManager (pseudo color image).

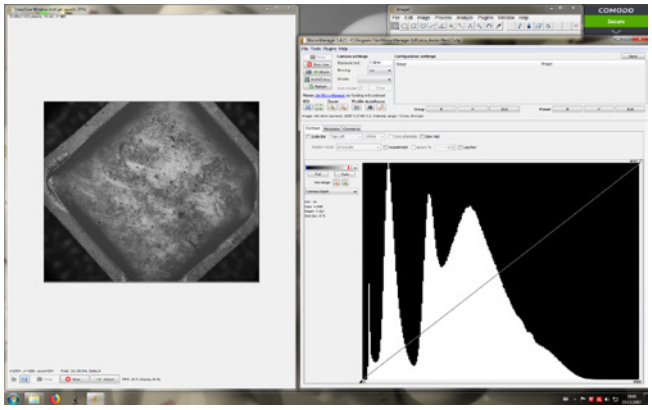

Fig. 4: Warm-white LED in MicroManager (monochrome display).

3. Testing the Neo-5.5

The images pictured in this chapter were taken by students during their mandatory practical exercises at our university and mostly show razor-sharp pictures with exceptional dynamic range which are a big step-up from our previous consumer-grade CMOS.
Although our USB3.0 camera yields true color images of for example LED phosphors, the Neo-5.5 enables finest details of every single LED component (see figure 5 and following).

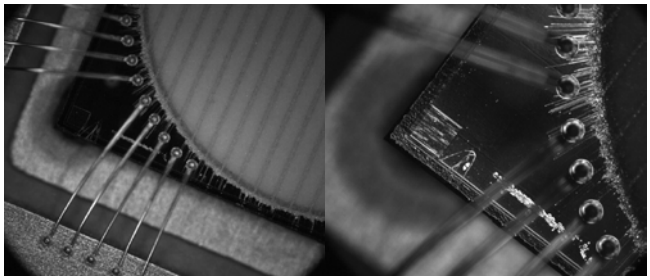

Fig. 5: Cold-white LED.

Fig. 6: Zoomed to the LED bonds.

One of the tasks for our students is to characterize cold-white and warm-white LEDs and LED phosphors. In the upper right part of figure 5 one can see the phosphors on the LED chip connected by the wires in the left picture section. Figure 6 is an enlarged section of the LED from figure 5.

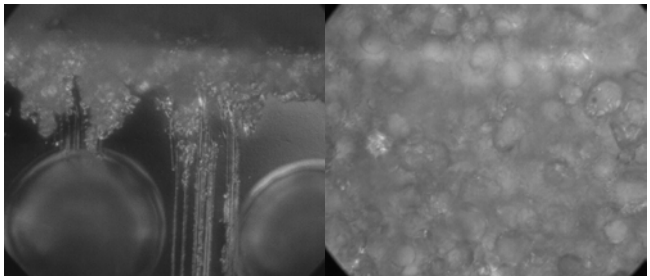

Fig. 7: Closer look to the bonds and phosphors.

Fig. 8: Phosphors of the cold-white LED.

In figure 7 the picture section around the bonds is scaled up once more. Figure 8 shows only one type of phosphors (potato-shaped) which is characteristic for cold-white LEDs.

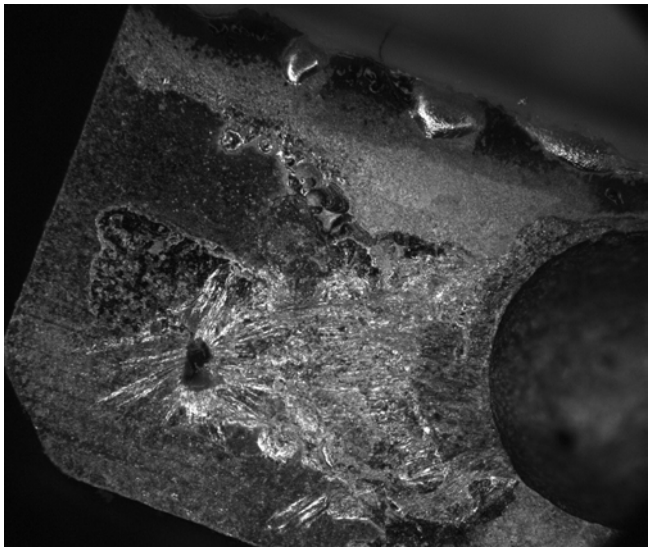

Fig. 9: Solder pad.

The result of a solder pad, where a LED was removed from, can be seen in figure 9. In the upper part of the picture, for example, one can still see the soldering tin.

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3.1 Z-Stack microscopy

As mentioned in chapter 2.2 our students also exercise with multidimensional microscopy that is shown in the next figures.

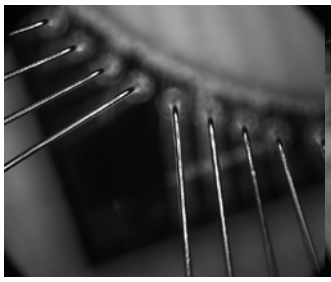

Fig. 10: Cold-white LED focused on the bonds.

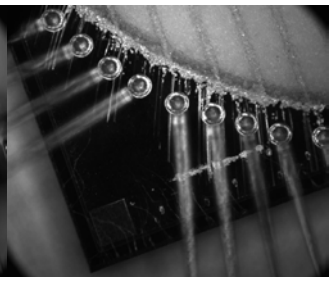

Fig. 11: Cold-white LED focused on the phosphor.

Figure 10 and figure 11 show a cold-white LED in different layers. In figure 10 the focus is on the LED bond wires, in figure 11 on the phosphor in the lower level. By means of ImageJ many of those images of different planes can be composed to one single picture as it is shown in figure 12.

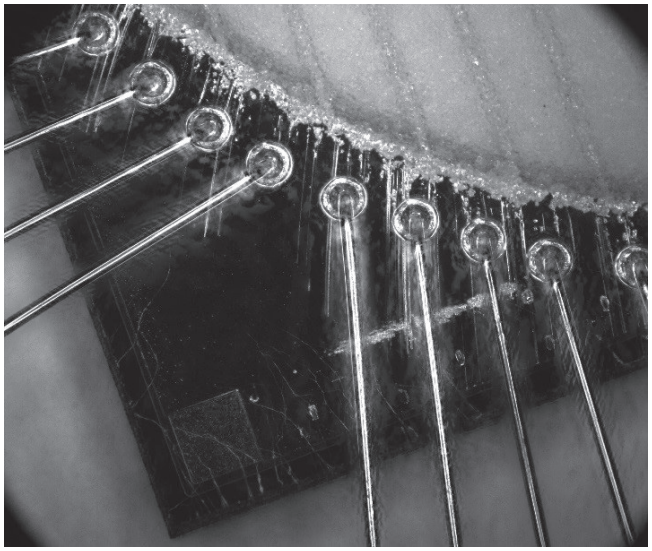

Fig. 12: Z-Stack microscopy of the cold-white LED.

Our students do the same exercises on warm-white LEDs. Figure 13 shows two different types of phosphors. We know the green marked potato-shaped phosphor from the cold-white LED (see figure 8), but here we also have distinctively different needle-shaped phosphor particles (red marked) which are characteristic for red nitride phophors.

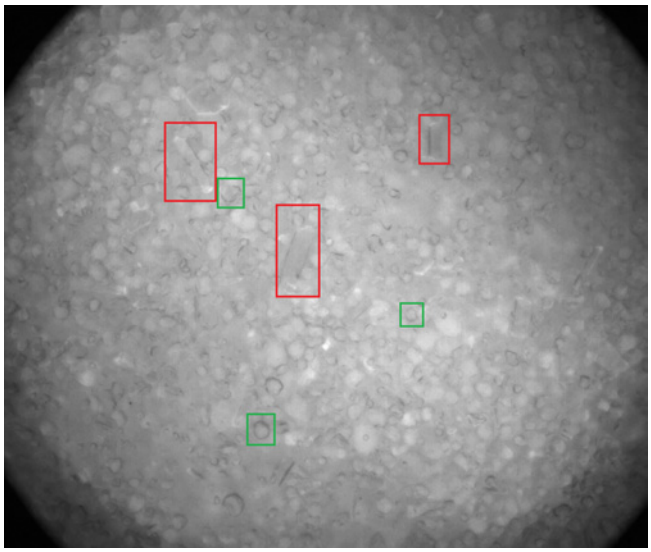

Fig. 13: Phosphors on a warm-white LED.

4. Conclusion

The Neo-5.5 is a great sCMOS camera with a wide application potential which we utilize to acquire very detailed microscopic images. We mostly use it for practical exercises at our university where students get to know the inner working of LEDs and learn to distinguish between different LED types. The performance of the Neo-5.5 far exceeds our requirements in terms of dynamic range, resolution and noise. Installation is straightforward, software interfacing is easy, even students with limited experience can reliably operate the camera. All in all, we are very satisfied with this camera.

5. Contact

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