Keywords: Luminescence, hyperspectral imaging, CRI index

Methods: Luminescence spectral measurements

Application: Material detection, color calibration

Hyperspectral imaging – hidden image detection using luminescence spectral measurements
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High speed electronics and high quality spectrometric tools have empowered the hyperspectral imaging as one of the main tools for finding objects, identifying some specific materials or detecting processes. It has found multiple applications in medicine, astronomy, surveillance and other. In this application note we use hyperspectral imaging for hidden image detection.

Background
The hyperspectral imaging is a spectral imaging technique that assigns spectral data of each pixel. Afterwards the spectral data can be manipulated so that it would give information of the materials or processes taking place in the area where the image was taken. In contrast, the human eye usually integrates the spectral image, thus in some cases cannot identify some materials or characteristics of the surface. This suggests that such hyperspectral imaging could become a standard tool for consumers for material and food control. In this application note we have implemented hyperspectral imaging for detecting hidden images. This approach is based on exciting luminiscent materials with UV light and then obtaining a luminescence hyperspectral imaging. The most important tool for this application is a spectrometer which allows collecting the spectral data from each of the image pixels.

Experimental setup
In principle the experimental setup for luminescence investigation and hidden image detection is quite simple and consists of some very basic components. It uses an arc xenon light source for the excitation of a point on the sample. The arc xenon lamp is very useful also for absolute color measurement since its spectra is close to the sun light spectra or in other words its CRI index is 96% which is very close to 1. The sample was put on a controllable XY table so that a XY scan of the image can be performed. A UV filter was put before the sample to ensure clean luminescence in the visible part of the spectra. The light was collected from the sample using a reflection/backscattering probe R400-7-UV-VIS, which ensures that the sample is excited and the light is collected from the same point (pixel). For registration of the spectra the USB2000+ UV-VIS spectrometer from OceanOptics was used. It covers the UV and visible ranges of the spectra and has sufficient resolution both for the wavelength and intensity. More importantly, it has very low noise range which is crucial for the low intensity luminescence measurements.

Results
Firstly, the setup is used toi nvestigate the excitation wavelength propeorties. Is excitation wavelength is formed using a xenon arc lamp and a bandpass filter. The transmission spectra or the filter is shown in Fig. 1. It has transmission of 14% at the peak wavelength of 325 nm.

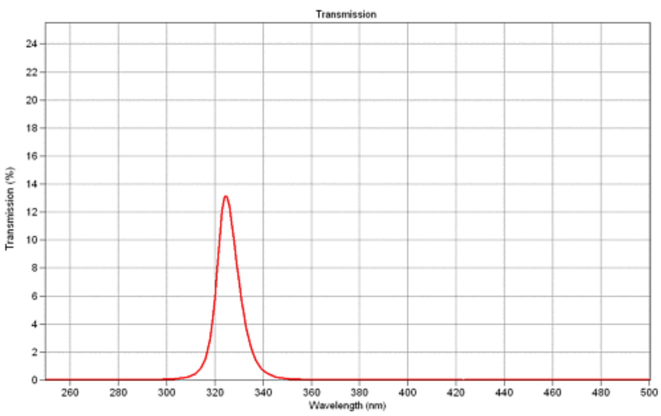

Fig. 1. Spectral transmission function of UV bandpass filter having transmission of 14% at the peak wavelength of 325 nm

Then the mentioned setup was used for the developed samples. The samples consisted of Zinc oxide (ZnO) and of Sodium bicarbonate. The first of two has luminescence in red part of the spectrum while the other has not. In Fig. 2 the obtained hidden image is shown. The value of each pixel was calculated using obtained CIE XYZ index which were then transformed to RGB values using matrix transformations. As can be seen s clear indication and position of ZnO can be obtained. It is important to note that the ZnO cannot be located by naked eye.

Fig. 2. Sample under investigation – ZnO on Sodium bicarbonate

Some additional colour pigments using the same approached were recorded. The results are shown in Fig. 3.

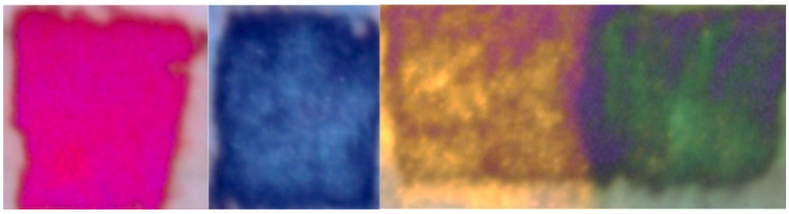

Fig. 3. Registered hyperspectral images of color pigments

Results

We have implemented a hyperspecral imaging technique based on single point luminescence measurement using a high resolution spectrometer USB2000+ UV-VIS. The simple technique has enabled us to locate hidden images in a mix of materials with different optical properties.