Plasmonic Nanoarrays
Darkfield Hyperspectral Microscopy

CytoViva® Illuminating the Future

Large scale efforts are underway to develop plasmonic nanoarrays to enhance a wide range of materials science and life science applications. Specific applications for plasmonic nanoarrays include enhancement of photo-imaging sensors, more effective energy harvesting in photovoltaics and the creation of biosensors for development of disease detection devices.

Development of effective plasmonic nanoarrays requires that the research team has an efficient method for quickly observing their nanoarrays and the ability to quickly measure the optical spectral response at each point in the array pattern. Without this capability, it can be difficult to confirm the efficacy and consistency of the nanoarray fabrication process. CytoViva's Enhanced Darkfield Hyperspectral Microscopy System has emerged as one of the most efficient and accurate methods for observing and measuring the optical spectral characteristics of nanoarrays.

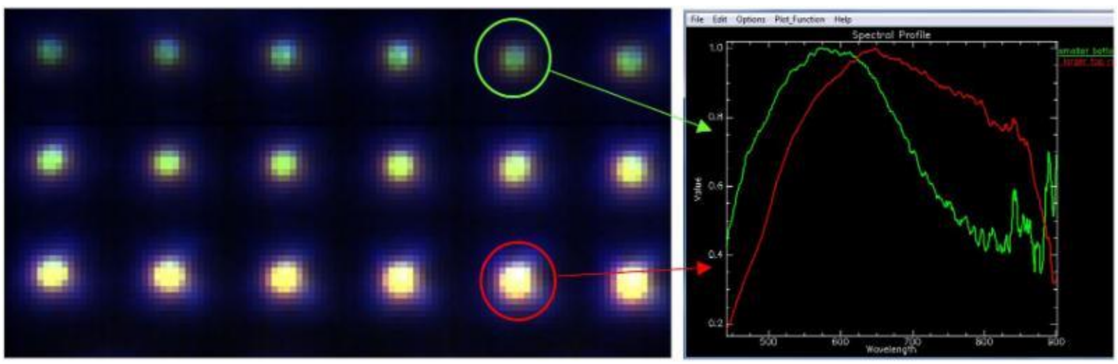

Figure 1: Reflected darkfield hyperspectral image of a plasmonic nanoarray of varying sized nanoparticles on an opaque substrate. (200x magnification).

Figure 2: Spectral response of two different nanoparticles within the array.

The high signal-to-noise nature of CytoViva's patented transmitted light enhanced darkfield optics enables rapid observation of the plasmonic scatter from nanoparticles as small as 10 nm in diameter. Standard reflected darkfield microscope optics can be used for nanoarrays on opaque substrates such as silicon. When the darkfield microscope is equipped with CytoViva's hyperspectral imaging, it can quickly capture high resolution spectral images of the nanoarray sample with every nanoscale pixel of the image containing the full optical spectrum. The spectrum contained in each pixel can cover either 400 - 1,000 nm in the VNIR range or 900 - 1,700 nm in the SWIR range. Spectral resolution can be as high as 1.5nm across the full VNIR range.

The image in figure 1 above illustrates a gold plasmonic nanoarray on a silicon substrate. This is a reflected light darkfield hyperspectral image. Note that the scatter in each row of the nanoarray shows different size particles. Also, there is a change in the color of the particles from green to yellow as the particle size increases. This redshift of the particles is due to the surface plasmon resonance (SPR) of the particles when illuminated with broadband illumination. This spectral response change is quantitatively measured by using hyperspectral imaging as shown in figure 2. Here, the smallest row of particles displays as a broad spectral peak at 550 nm while the larger particles have redshifted with a spectral peak at 650 nm. It is also producing significantly more spectral response in the NIR range past 700 nm.

Quartz halogen broadband illumination is often used to capture these hyperspectral images across a wide range of different fabricated nanostructures including plasmonic, metal oxide, and even some photoluminescent nanomaterials such as perovskites. However, different illumination options including coherent light can also be used. At 100x magnification, areas as large as 900 µm x 900 µm can be captured in as little as three to five minutes. Pixels sizes containing the full optical spectral response can be as small as 128 nm when using 100x magnification. In spite of the high volume spectral - spatial nature of this technique, hyperspectral imaging is considered a high throughput methodology relative to most other techniques.

CytoViva's Enhanced Darkfield Hyperspectral Microscopy System provides a fast and highly reliable method for confirming the consistency of the nanoparticle SPR effect across the nanoarray and measuring expected changes in the SPR based on nanoparticle size or surface chemistry changes. In addition, this is highly complementary data that can be cross correlated with Raman, which measures the Surface Enhanced Raman (SERs) effect of specific proteins that are often added to these plasmonic nanoparticles. To accommodate this cross correlation measurement of SPR and SERS of the same sample, CytoViva and HORIBA Scientific have created a multi-modal microscope system which combines both darkfield optical hyperspectral imaging and Raman onto a single platform.

CytoViva's Enhanced Darkfield Hyperspectral Microscopy System is now utilized by hundreds of research groups around the world. Many of these groups are involved in fabrication of nanoarrays. Links to two abstracts of recent publications using CytoViva's Enhanced Darkfield Hyperspectral Microscopy System on plasmonic nanoarrays are listed below.

Zhang, Shuaidi and Yu, Shengtao and Zhou, Jing and Ponder, James F. and Smith, Marcus J. and Reynolds, John R. and Tsukruk, Vladimir V. "Heterogeneous forward and backward scattering modulation by polymer-infused plasmonic nanohole arrays." Journal of Materials Chemistry C, 7, no. 10, 3090-3099 (2019)

Hangyong Shan, Ying Yu, Xingli Wang, Yang Luo, Shuai Zu, Bowen Du, Tianyang Han, Bowen Li, Yu Li, Jiarui Wu, Feng Lin, Kebin Shi, Beng Kang Tay, Zheng Liu, Xing Zhu & Zheyu Fang. "Direct observation of ultrafast plasmonic hot electron transfer in the strong coupling regime." Light: Science & Applications, 8:9 (2019)

To learn more about CytoViva's Enhanced Darkfield Hyperspectral Microscopy System or how it can help you with your nanoarray or related research, please contact us at info@cytoviva.comor visit our website www.cytoviva.com. We will be pleased to discuss your research and test imaging of your samples.