Imaging of viruses with the help of surface plasmons

For a long time biosensors based on the surface plasmon resonance (SPR) phenomenon were not considered as effective tools to detect and visualize the binding of individual nano-scale objects to the functionalized sensor surface. However, innovative studies performed by scientists in independent research groups helped to recognize full potential of SPR-based sensors in studies of biological and non-biological nano-particles. SPR imaging (SPRi) technique assisted in visualization the binding of individual influenza A viral particles and HIV virus-like particles (HIV-VLPs) to the sensor surface.

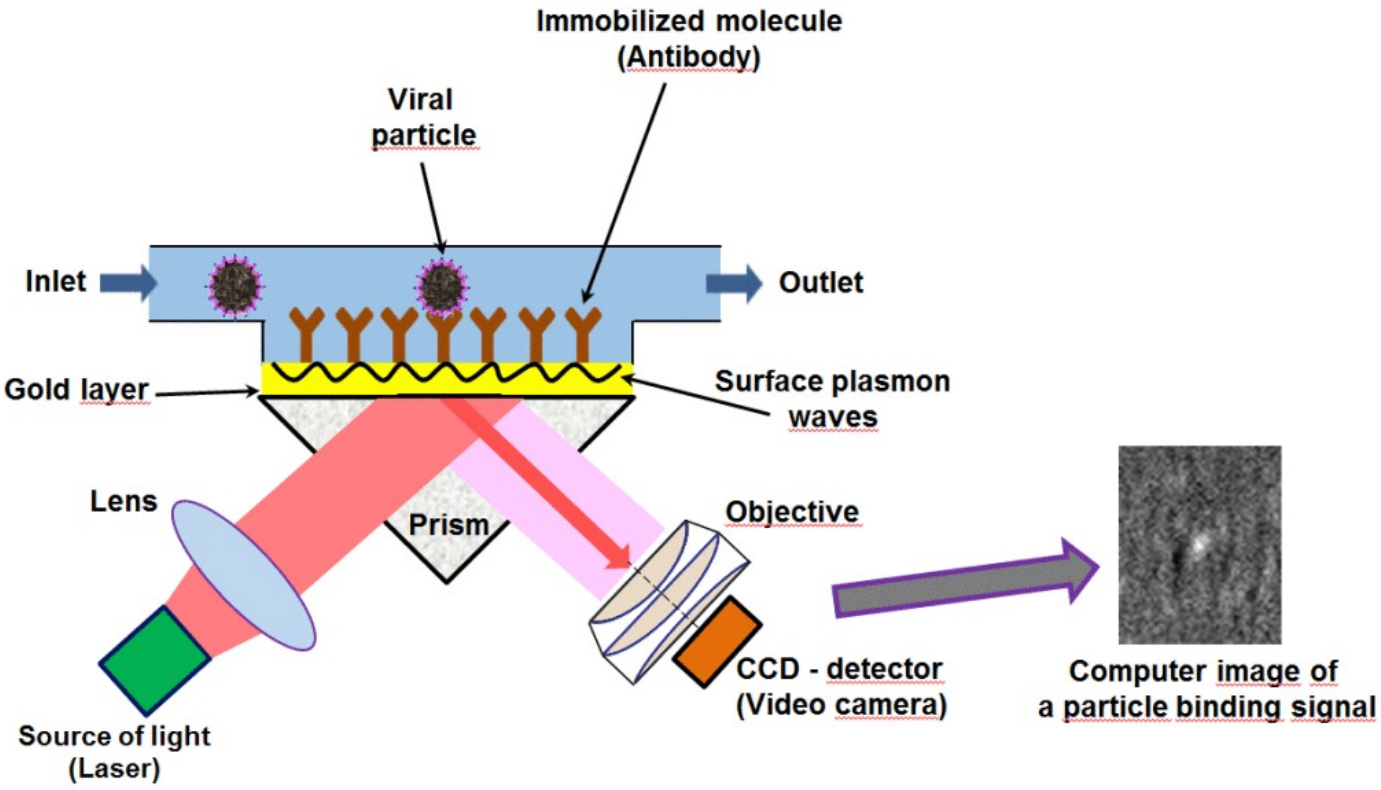

Fig. 1. Scheme of SPRi-based sensor experimental set up and an example of computer-processed image of the binding of HIV-VLP to the sensor surface.

How does the SPR imaging of individual nanoparticles work? Trying to simplify many details and keeping in mind that some of them are still intensively investigated, one may describe this process in the following way (Fig. 1). A “heart” of the sensor system is a glass prism covered with a gold layer of about 50nm thickness. This gold layer represents the sensor surface, which is illuminated by a laser beam through a prism and can be functionalized by antibody against viral particles. At a particular incidence angle a laser beam excites collective electron vibrations in the gold layer.

These vibrations are called plasmons. Thus, the appearance of plasmons indicates a transformation of the incidence light energy into the energy of moving electrons. This energy transformation prevents reflection of the incidence light at the definite incidence angle. Thus, reflected light disappears almost completely and the image of the sensor surface caught by a video camera and transferred to a computer remains practically black. Moreover, the sensor surface of the gold layer becomes very sensitive to even small disturbances. Appearance of such disturbances after an event of particle binding to the gold surface leads to local changes of reflectivity conditions. Reflectivity enhances. In turn, the binding event of an individual particle causes a bright spot on the image of the sensor surface and can be detected by the video camera.

In the recent work, Shpacovitch and colleagues used a SPRi-based sensor to perform real-time observations of the binding of label-free biological particles to a sensor surface. HIV-VLPs, inactivated influenza A, and tobacco mosaic virus (TMV) particles were used as models. The authors demonstrated the applicability of SPRi-based sensor for specific detection of biological submicrometer-particles. Spherical viral particles were visualized without difficulties. However, it was not possible to visualize TMV particles using presented SPRi-sensor. A question whether the shape of a viral particle may influence its visibility by SPRi-sensor needs further investigation. Moreover, the SPRi-sensor is applicable for the determination of relative particle concentrations in solutions. Thus, concentration measurements of viruses can be performed after appropriate calibration.

Zest of the SPRi-based sensor is its ability to perform direct measurements and visualization of viral particles. Detected signals are attributed to viral particles themselves, not to their structural proteins or genetic material. This technique is also faster than the majority of currently used direct methods and it does not require intensive labor procedures. The analysis of samples using SPRi-sensor requires usually minutes and only in the case of low concentration samples can take hours. Commonly used direct methods often require days for analysis. Thus, the SPRi-based sensor can be an invaluable tool for an early diagnostic of viral diseases. However, the application field of this sensor can be expanded to the detection and quantification of other biological nano-particles: drug delivery particles or extracellular vesicles.

Publication

Application of surface plasmon resonance imaging technique for the detection of single spherical biological submicrometer particles.
Shpacovitch V, Temchura V, Matrosovich M, Hamacher J, Skolnik J, Libuschewski P, Siedhoff D, Weichert F, Marwedel P, Müller H, Überla K, Hergenröder R, Zybin A
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