Plasmon-enhanced fluorescence biosensors: amplification strategy in fluorescence assays

Jakub Dostalek, AIT-Austrian Institute of Technology, Muthgasse 11, Vienna 1190, Austria.
jakub.dostalek@ait.ac.at.

Fluorescence represents (arguably) mostly used optical method for detection of chemical and biological species in important fields of medical diagnostics, food safety and security. However, the sensitivity of fluorescence-based technologies needs to be further advanced in order to fulfill increasing demands for rapid detection of trace amounts analytes. The amplification of fluorescence signal through the coupling of fluorophore labels with metallic nanostructures (see Fig. a) represents an attractive way for advanced fluorescence assays [1]. This approach is referred as plasmon-enhanced fluorescence (PEF) and it takes advantage of the combination of a) increasing the excitation rate at the fluorophore absorption wavelength (λ_{ab}), b) decreasing background by the highly confined surface plasmon electromagnetic field intensity, c) increasing the photo-stability of fluorophores via decreasing their lifetime and d) enhancing the efficiency of collecting the fluorescence light by using highly directional plasmon-coupled emission at the emission wavelength (λ_{em}), see Fig (a).

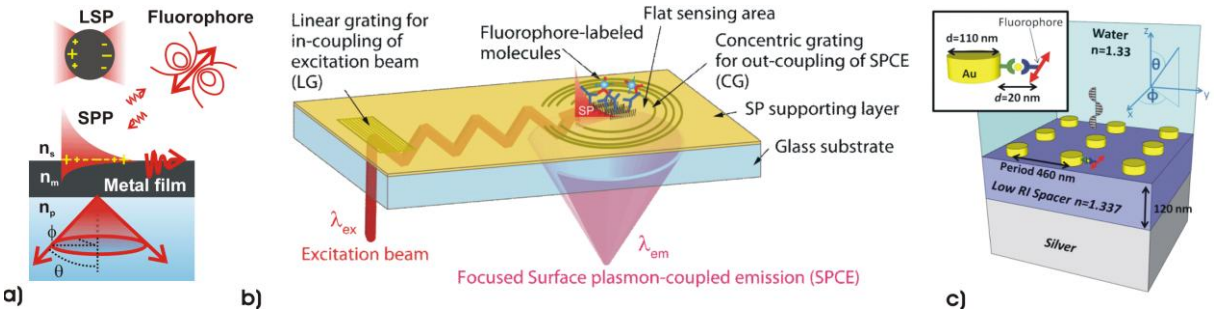

Fig. a) Schematic of surface plasmon interaction with fluorophore labels, b) compact biochip with implemented PEF that utilizes propagating surface plasmons, c) collective localized surface plasmons for PEF.

The lecture will describe several approaches in PEF that were recently carried out in our laboratory and which allow for enhancing signal in fluorescence assays by several orders of magnitude. In particular, the employing of collective (lattice) localized surface plasmons (cLSPs) on arrays of diffraction-coupled metallic nanoparticles will be discussed (see Fig c) [2]. In addition, our efforts on implementation of PEF either to existing analytical instruments or to new compact portable devices by using diffractive elements [3] (see Fig. b) will be presented. The performance of PEF will be illustrated by several assays for detection of molecular analytes at low-femtomolar concentrations [4] and harmful bacterial pathogens at concentrations as low as 10 colony forming units [5].

References

1. J. Dostalek, and W. Knoll, "Biosensors based on surface plasmon-enhanced fluorescence spectroscopy," Biointerphases **3**, 12-22 (2008).
2. M. Bauch, and J. Dostalek, "Collective Localized Surface Plasmons for High Performance Fluorescence Biosensing," Optics Express **21**, 20470-20483 (2013).
3. K. Toma, M. Toma, P. Adam, M. Vala, J. Homola, W. Knoll, and J. Dostalek, "Surface plasmon-coupled emission on plasmonic Bragg gratings," Optics Express **20**, 14042-14053 (2012).
4. Y. Wang, A. Brunsen, U. Jonas, J. Dostalek, and W. Knoll, "Prostate Specific Antigen Biosensor Based on Long Range Surface Plasmon-Enhanced Fluorescence Spectroscopy and Dextran Hydrogel Binding Matrix," Analytical Chemistry **81**, 9625-9632 (2009).
5. C. J. Huang, A. Sessitsch, J. Dostalek, and W. Knoll, "Long range surface plasmon-enhanced fluorescence spectroscopy biosensor for ultrasensitive detection of E. coli O157:H7," Analytical Chemistry **83**, 674–677 (2011).