Università Ca'Foscari Venezia
Dipartimento di Scienze Molecolari e Nanosistemi

ISTITUTO ITALIANO DI TECNOLOGIA
CENTER FOR CULTURAL HERITAGE TECHNOLOGY

Seminar

Organic Optoelectronic Components in a Smart-integrated System for Plasmonic-based Sensing

Stefano Toffanin

Institute for the Study on Nanostructured Materials (ISMN), National Research Council (CNR)

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Abstract

The continuous growth of the global population has been remarking the need of early detection systems to prevent the spread of epidemics as well as to improve the standards of living. The emerging demand of sensing technologies has prompted researchers and industrial companies to develop devices able to monitor medical, food, water, and environmental safety/quality indicators in an efficient, simple, and reliable way. While high sensitivity and selectivity must be guaranteed, compactness, user-friendliness and low-cost are key characteristics to enable the use of the sensing technology for point-of-care diagnostics without the need for trained personnel[1].

Among state-of-the-art methodologies for pollutants detection, optical sensing has emerged as one of the most simple, versatile, and powerful approaches for analytical purposes. However, a major obstacle towards the development of a portable system has been the use of bulky optical components (e.g. lasers and optical fibers), which are necessary to ensure a good sensing capability. In particular, huge interest has been attracted by functionalized metallic surfaces based on surface plasmon resonance (SPR), as extremely sensitive, label-free, quantitative systems for real-time detection of single or multiple analytes. However, the need of a fine and precise control of the angle of the incident light ended up in the use of not-portable optical components in the final sensor [2].

In this scenario, organic optoelectronic components might enable the definition of new miniaturized detection schemes to boost the advent of compact optical sensors for on-site analysis, given their inherent capability of smart monolithic integration in nm-thick multi-stack devices on almost any surface.

Here, we report an unprecedented ultra-compact system endowed with optical and plasmonic sensing capabilities through the smart integration of (i) organic light-sources such as organic light-emitting diodes (OLEDs) or transistors (OLETs), (ii) an organic light-detector such as organic photodiode (OPD) and (iii) a sensing nanostructured surface such a nanoplasmonic grating (NPG) [3]. The components and the layout of integration were suitably designed to make the elements work cooperatively in a reflection-mode configuration. In particular, the OPD was vertically stacked onto the source electrode of the OLET thus providing electrical switching, light-emission and light-sensing capability in a single organic multilayer architecture. When coupled to the NPG, a multifunctional system with SPR-sensing ability was obtained at a remarkably high level of miniaturizationat a sensor size as low as 0.1 cm^3, arising from the direct fabrication of the NPG onto the encapsulating cap of the light-emitting/-sensing platform [4].

The sensor provides quantitative and linear response reaching a limit of detection of 10^{-4} refractive index units once it is calibrated by standard solutions. Analyte-specific and rapid (15 min long) immunoassay-based detection is demonstrated for targets relevant for the milk chain. By using a custom algorithm based on principal-component analysis, a linear dose–response curve is constructed which correlates with a limit of detection (LOD) as low as 3.7 μg mL^{-1} for lactoferrin, thus assessing that the miniaturized optical biosensor is well-aligned with the chosen reference benchtop SPR method.

[1] R. Dragone, G. Grasso, M. Muccini and S. Toffanin Frontiers in Public Health, 2017, 5, 1.
[2] M. Prosa, ..., S. Toffanin, Nanomaterials2020, 10, 480.
[3] M. Bolognesi, ..., S. Toffanin Adv. Mater. 2023 2208719
[4] M. Prosa, ..., S. Toffanin, Adv Funct Mater 2021, 31, 2104927.

The organizers
Dr. Mauro Moglianetti, IIT
Dr. Domenico De Fazio, DSMN