Integration of multilayer QLED source on portable prism-based SPR sensors for water pollutant detection.

Margot Ballini[1], Laurent Oyhenart[1], Pauline Girault[2], Emilie Hubert[1] and Isabelle Bord Majek[1]
1: Laboratoire de l'Intégration du Matériau au Système (IMS), Université de Bordeaux, UMR CNRS 5218, Bordeaux INP, 33400, Talence, France
2: Univ. Bordeaux, CNRS, Bordeaux INP, ICMCB, UMR 5026, F-33600 Pessac, France

According to environmental and societal issues, detecting water pollutants as heavy metals is a huge challenge for human health and biodiversity [1-2]. Traditional techniques such as chromatography and spectroscopy can provide reliable and conclusive results, but do not offer the portability for real-time in-situ analysis or the ease of use of Surface Plasmon Resonance (SPR) sensors [3]. Conventional SPR systems still have limitations which motivate the development of new architectures and new monitoring strategies [4-5].

Our overall project aims to develop a lab-on-chip SPR sensor by initially integrating the light source on the right-angle prism face using a quantum-dots (QD) light emitting device (QLED) [6]. QD nanoparticles (1–10 nm) are attractive light emitters due to their narrow emission bandwidth, their tunable visible-range emission, and semiconductors advantages such as high physicochemical stability, long lifetime, and strong luminance compared to organic emitters.

We have manufactured a 400 nm-thick multilayer QLED based on Cd@Se nanoparticles (emission wavelength of 548 nm) using spin coating and thermal evaporation [7]. After encapsulation, the obtained QLED achieves an External Quantum Efficiency of 6% and a luminance of 27100 cd/m^2 for an effective 14 mm^2 surface with a 32 nm Full Width Half Maximum.

Using this QLED, the SPR sensor (50 nm gold film) leads to an experimental resonance angle in air of 43.7°, in good agreement with both calculated (45.8°) and measured (44.4°) angles with a conventional laser SPR bench [8]. These first results are obtained at 548 nm, which is the suitable wavelength for chrome VI sensing. Modifying the size and/or the composition of the QD, any wavelength can be achieved, expanding the range of detectable analytes.

The wavelength-tunable multilayer QLED was efficiently integrated on a prism-based SPR sensor, demonstrating the feasibility of a compact and low-cost plasmonic sensing device for health and environmental applications.

[1] Fernández-Luqueño, F.; López-Valdez, F.; Gamero-Melo, P.; Luna-Suárez, S.; Aguilera-González, E. N.; Martínez, A. I.; García-Guillermo, M. D. S.; Hernández-Martínez, G.; Herrera-Mendoza, R.; Álvarez-Garza, M. A.; Pérez-Velázquez, I. R. Heavy Metal Pollution in Drinking Water - a Global Risk for Human Health: A Review. African Journal of Environmental Science and Technology 2013, 7 (7), 567–584.

[2] Santé publique France. Étude de santé sur l'environnement, la biosurveillance, l'activité physique et la nutrition (Esteban). Consulté sur https://www.santepubliquefrance.fr/etudes-et-enquetes/esteban

[3] Pluchery, O.; Bryche, J.-F. An Introduction to Plasmonics; 2023. https://doi.org/10.1142/q0395.

[4] Guner, H.; Ozgur, E.; Kokturk, G.; Celik, M.; Esen, E.; Topal, A. E.; Ayas, S.; Uludag, Y.; Elbuken, C.; Dana, A. A Smartphone Based Surface Plasmon Resonance Imaging (SPRi) Platform for on-Site Biodetection. Sensors and Actuators B: Chemical 2017, 239, 571–577. https://doi.org/10.1016/j.snb.2016.08.061.

[5] Hausler, P. Surface Plasmon Resonance as a Technology for Miniaturized Sensor Systems. phd, Universität Regensburg, Regensburg, 2025. https://doi.org/10.5283/epub.58966.

[6] Kim, J.; Roh, J.; Park, M.; Lee, C. Recent Advances and Challenges of Colloidal Quantum Dot Light-Emitting Diodes for Display Applications. Advanced Materials 2024, 36 (20), 2212220. https://doi.org/10.1002/adma.202212220.

[7] Cao, W.; Xiang, C.; Yang, Y.; Chen, Q.; Chen, L.; Yan, X.; Qian, L. Highly Stable QLEDs with Improved Hole Injection via Quantum Dot Structure Tailoring. Nat Commun 2018, 9 (1), 2608. https://doi.org/10.1038/s41467-018-04986-z.

[8] Mukhtar, W. M.; Murat, N. F.; Samsuri, N. D.; Dasuki, K. A. Maximizing the Response of SPR Signal: A Vital Role of Light Excitation Wavelength. AIP Conference Proceedings 2018, 2016 (1), 020104. https://doi.org/10.1063/1.5055506.