Applications of nanophotonics and nanotechnologies to life sciences

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Abstract

In this communication, new results carried out at the Institute for Microelectronics and Microsystems of the National Research Council of Italy, with perspective applications in the field of biomedicine, will be presented and discussed. They exploit the advance in nanotechnologies and nanophotonics for the realization of new devices characterized by unexpected behaviours and performance, such as nano-biosensors and biochips, microfluidics for cell manipulation, and drug delivery and administration micro/nanosystems. The devices and systems exploit new concepts, and take advantages of the know-how and technologies developed by the research group in optoelectronics.

In particular, the realization of efficient label-free optical sensor arrays based on silicon nanostructures, and their exploitation in a lab-on-chip configuration, will be reported. The sensing platform can be integrated with a new class of devices, competitive with plasmonic ones, exploiting resonances supported in a photonic crystal metasurface. Molecular binding is detected as a shift in the resonant wavelength of the bound states in the continuum of radiation modes. The new configuration, applied to the recognition of protein-protein interactions, demonstrates excellent stability, loss-free operation, minimal optical interrogation equipment, and the broadband operation capability.

Moreover, microfluidic circuits for cell manipulation will be presented, together with new drug delivery and administration systems based on porous materials. A first approach is based on biosilica nanoparticles (NPs) obtained from diatomites as non-toxic nanovectors of therapeutic agents in cancer cells. The internalization kinetics and intracellular spatial distribution of functionalized NPs incubated with human lung epidermoid carcinoma cell line are investigated by Raman imaging. The label-free Raman results are compared with confocal fluorescence microscopy and photoluminescence data. The second approach exploits a new hybrid patch for local administration of drugs, based on polymeric micro-needles and a porous silicon free-standing membrane. The porous silicon multilayer not only increases the storage of a relevant amount of the drug, but also offers a continuous, naked-eye monitoring of the drug delivery process.