Nanostructured silicon - a platform for biophotonics

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The future of modern society is tied to the availability of sustainable energy resources and effective diseases diagnostics and therapy. Over the last years, top-down and bottom-up silicon nanostructures have been favored in my group at Leibniz IPHT [1-3] as a promising highly effective optoelectronic and (bio)photonic material due to a number of unique physical-chemical properties. In frame of presented paper I am going to speak about three concepts related to the biosensing and theranostics applications based on silicon technology.

The targeted scientific breakthrough of the first task is related to the controlled and self-organized process of localized nanostructures in porous silica matrix on silicon surface where dielectric pores are selectively filled by plasmonically active metals [4-6]. The results presented in this part are highly useful for the design of plasmonic-active surfaces for surface enhanced Raman spectroscopy-based detection of ultra-low concentration of different chemical or biological analytes, where the size of the localized nanostructures is comparable with the spot area of the focused laser beam.

From another side, Surface Enhanced Raman Spectroscopy (SERS) in the deep UV range (< 300 nm) has not yet been systematically explored and applied, but it could be very promising for the structural analysis of proteins and DNAs. For that reason, it is necessary to find cost-efficient and effective alternatives, which could also be used for SERS in broad spectral range, between UV and IR range (250 nm and 800 nm). One of the candidates is a metallic tin (Sn) and metal/metal oxide core-shell structures. In this part I will present a novel effect [7] that corresponds to the disproportionation of thermodynamically stable tetragonal tin dioxide (SnO_2) phase along the silicon nanowire length to lower tin states such as tin monoxide (SnO) and metal tin (β-Sn) on nanostructured silicon surfaces, compared with pure SnO_2 phase on planar surface.

In the last part of my presentation I will discuss nanoparticles of mesoporous silicon (PSi NPs) which have undeniable advantages when used as nanocontainers (NCs) for the drug delivery, due to their unique properties, such as high biocompatibility, biodegradability in non-toxic silicic acid, high loading efficiency for the delivery of both hydrophilic and hydrophobic drugs, adjustable sizes of meso-pores for the delivery of molecules of different sizes, the possibility of chemical functionalization for targeted delivery [8-10].

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