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Porous semiconductor compounds: characterization and applications

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Over the last two decades, it has been demonstrated that electrochemistry is one of the most accessible and cost-effective approaches for nanostructuring semiconductor materials in a controlled fashion. Moreover, taking into account that electrochemical nanostructuring in NaCl-based neutral electrolyte of semiconductor compounds such as InP, GaAs, and GaN was demonstrated, we succeeded to make this method also environmentally-friendly [1].

Semiconductor compounds in comparison with Si provide more space for tailored nanofabrication in terms of compositions, bandgaps, mechanisms of the pore growth and new properties with large potential for applications. Besides, semiconductor nanotemplates which properties can be easily controlled by external illumination, applied electric fields etc. provide wider possibilities for nanofabrication, compared with dielectric nanotemplates. Combining two methods, namely electrochemical etching and electrochemical deposition, one-dimensional nanostructures such as nanowires, nanotubes and their networks have been successfully fabricated.

Metal nanodots are obtained routinely in solutions, but positioning them on a chip remains a significant challenging. Conventional controlled patterning approaches like electron beam lithography, stencil lithography, and extreme ultraviolet interference are very expensive.

The walls of the porous semiconductor skeleton, exhibiting good electrical conductivity in comparison with the walls of dielectric nanotemplates, create good conditions for uniform nucleation of metal dots. Along with this, one monolayer of gold nanodots on porous semiconductor structures can be deposited using the so-called "hopping electrodeposition" [2]. In particular, uniform deposition of Pt on the inner surface of pores was demonstrated, regardless of the pore shape (e.g. circular, triangular-prism like pores etc.) [3].

The report will focus on different aspects of pore growth, transition from the porous semiconductor structures to the formation of semiconductor nanowires, as well as technologies for controlled electrochemical deposition of metal nanostructures into porous semiconductor templates. The obtained metal-semiconductor structures were exploited in a variable capacitance device elaboration with a record capacitance density variation of about 6×10^{-3} pF/V per $1 \mu\text{m}^2$ of surface [3]. An IR photodetector based on a single GaAs nanowire with good sensitivity and dynamic characteristics was demonstrated [4]. The fabricated core-shell GaAs/Fe nanowire arrays, along with possibilities to tune the orientation to the substrate surface, showed magnetic anisotropy with respect to the coercivity and the remanence ratio [5].

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