NEW PRINCIPLES OF NANOMANIPULATION AND NANOASSEMBLING OF INDIVIDUAL NANOOBJECTS FOR FUNDAMENTAL RESEARCH

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At present, nanomanipulation and nanoassembly technologies are decisive in opposing paradigms of «top-down» and «bottom-up», which is observed in modern nanotechnology. This report offer the development of new advanced technologies for nano-manipulation and nano-integration of individual nanoobjects with the help of the new mechanical and optical nanotweezers for chemical synthesis, fundamental research of bio-nano-objects and design of bio-nanodevices and nanomaterials.

The original concept of the optical ring resonator (PANDA-resonator) [1], which can be used as an optical nano-tweezers [2] has been developed theoretically. In a liquid media, these optical nanotweezers can be used for the basic research and processing of individual bio-nano objects, including cells, viruses, nanomotors, etc. Recently, new frontier systems of mechanical nano-manipulation [4] based on the World's smallest thermally controlled nano-tweezers [3], have been experimentally implemented, too. The nanotweezers are produced from smart nanostructures shape memory alloys composite and is used for pick up and place, preparing, etc and assembling individual nano-objects in a vacuum environment of electron and ion microscopes [5].

For realization of these approaches, one needs the individual nano-objects (nanowires, nanotubes). In [6], it has been reported about the developed of amyloid-like peptide-based nanostructures and Pd-nanowires; in [7] the authors describe preparing of functional nanowires. These nanostructures, nanowires, nanotubes will be used for the experimental creation of the optical ring resonator (PANDA-resonator) and the optical nano-tweezers, based on this PANDA-resonator.

Individual nano-objects demonstrate the unique functional properties and allow for creation of separate nano-devices for nanoelectronics, nanophotonics, nanoplasmonics, nanosensorics and bio-nanotechnology [3]. These unique functional properties provides the opportunity for nano-devices to diminish their size and to reach better parameters, then those, which can be reached under the limitation of top-down nanolitography methods [3]. Novadays much attention and effort were paid for creation of single nano-devices from individual nano-objects like nanowires, nanotubes, nanoparticles, graphen layers and so on. In the given report, it is proposed for the first time in the World to create and test the technology presenting two different kinds of tweezers for nanomanipulators and nanoassembling at the same time, namely optical and mechanical ones. The developed hybrid bottom-up technology will be used for creation of new class of ordered porous nanomaterials, nano-biomanipulation and so on.

There is the visualization of the approaches on the pictures below. On Figure 1, the schematic diagram of the ring PANDA resonator [1] is shown. Figure 2 a)-i) displays the mechanical nanotweezers (a) and detailed process of CNT nano-manipulation (b-i) using this mechanical nanotweezers.

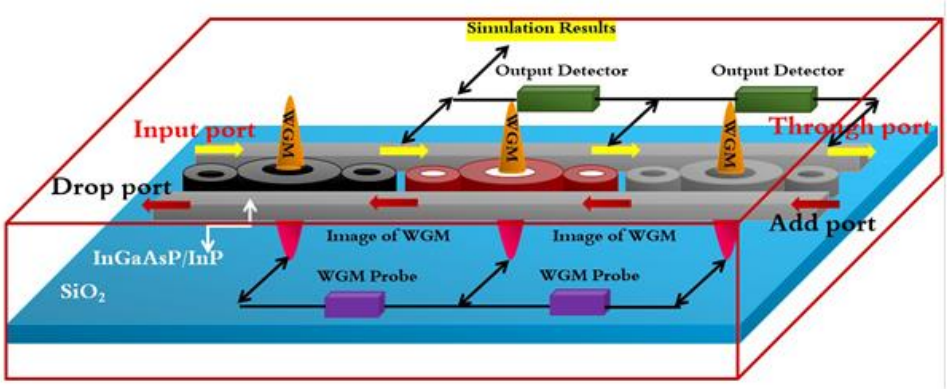
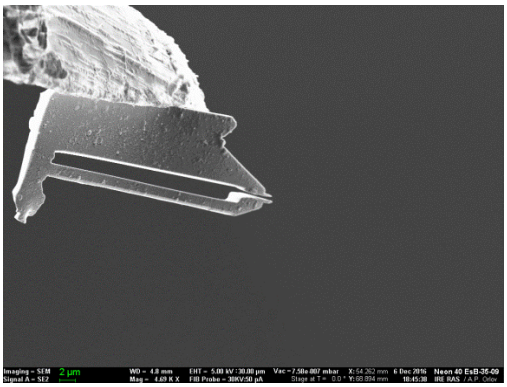
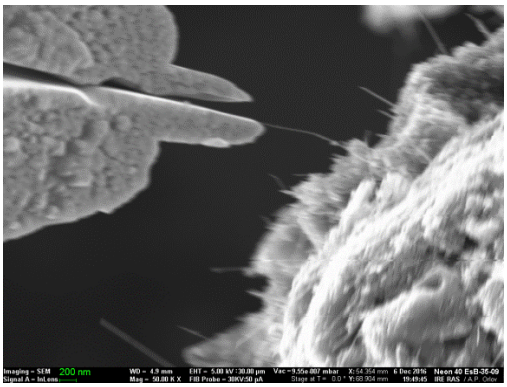
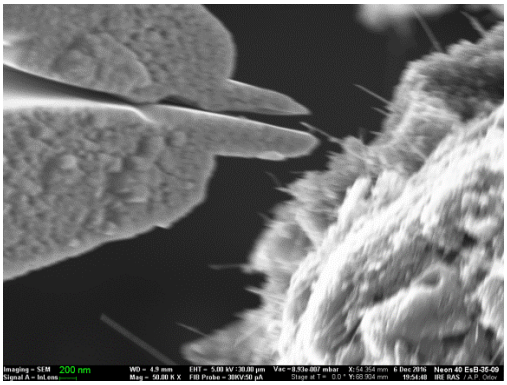


Figure 1 – A Schematic diagram of the ring PANDA resonator [Applied Optics, 55(33), 9504-9513, 2016], from which the tweezers probe can be generated and used for atom/molecule trapping applications. The whispering gallery mode (probe) can be generated and controlled to be the two side probes, where one side is used for trapping, the other side for delivering (releasing), while the beam side and trapping force can also be controlled suitably for the individual atom/molecule size


a


b


c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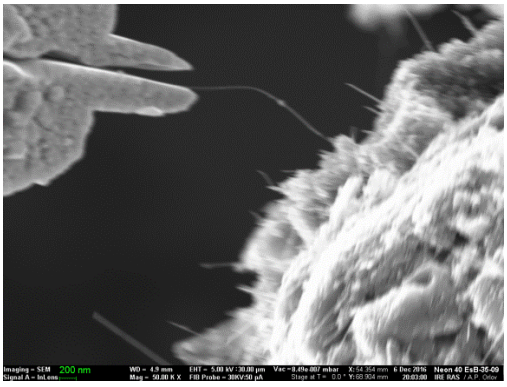
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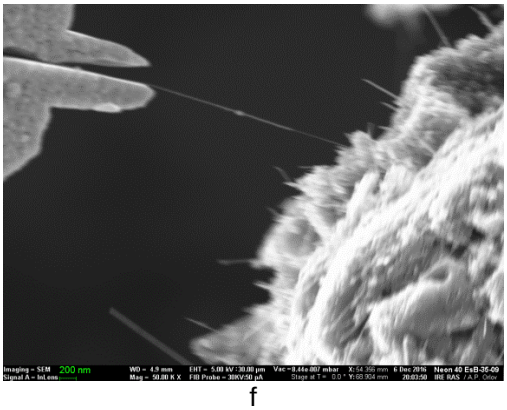
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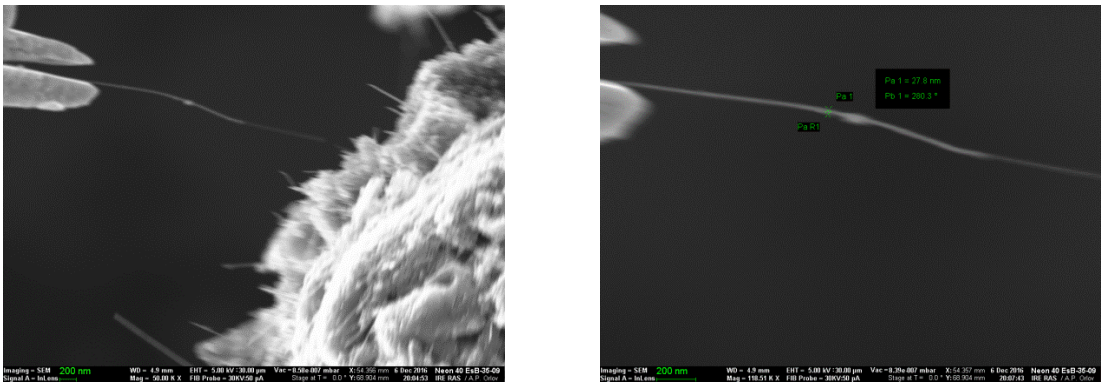

g i

Figure 2 – Mechanical nanotweezer (a) and detailed process of CNT manipulation (b-z) mechanical nanotweezer

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