The NPS4FM Project Summary.

The special structure of nanomaterials gives rise to their amazing properties. The ability to manipulate the structure and composition on the nanoscale provides very large opportunities to create new materials with superior performance for new products and devices. Since optical properties of nanomaterials can be controlled by changing their size, shape and aspect ratio, as well as via their surface modification, nanomaterials are prime candidates as building blocks for photonic sensors.

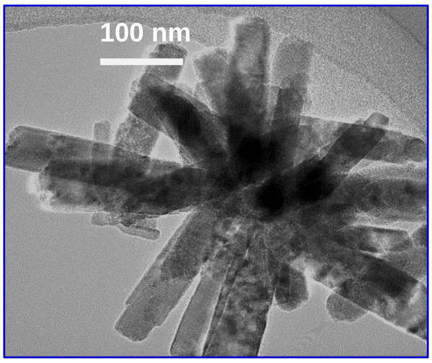


Fig.1. ZnO nanorods generated via ablating Zn target by millisecond laser in water medium.

In this project (NPS4FM), we prepared ZnO, $SnO_2$, CdO and CdS nanostructures with different sizes and morphologies, as shown in Fig 1, via the laser ablation in liquid and wet-chemistry approach. The nanomaterials were prepared with pure or passivated surfaces, which was realized either in situ or ex situ, i.e. during the material preparation or afterwards, if necessary. The resulting materials were used as a nano-ink in order to print functionalized nanomaterials on different substrates, including optical quartz and Si wafers. Additionally, we successfully developed porous biomorphous SiC ceramics that are potentially applicable as support for catalysts or gas-sensing materials. Finally, we investigated a range of bacteriophages aiming at finding a suitable system for fluorescent detection of food bacteria. Currently, the T4 bacteriophage and LAMBDA phage are defined as promising materials for photoluminescent detection of *E. coli*. The follow-up research activities will include investigation of bacteria- sensing properties of semiconductor oxide nanoparticles- bacteriophage systems.

We achieved the following major results.

1) For the first time, the effect of pressure on the properties of ZnO nanoparticles laser-generated in liquid phase at different pressures was studied using water-ethanol mixtures as the liquid mediuma. It was demonstrated that the optical properties, such as photoluminescence, of nanoparticles produced in different media and at different pressures were different and thus could be controlled by both medium chemistry and pressure. This is explained by different defects and surface states forming in ZnO nanoparticles that grow under different conditions. A research paper was published on the obtained results. In parallel, another research paper is being prepared on the effect of laser pulse parameters on both the chemistry and morphology of produced $SnO_2$ nanomaterials.

2) Using laser irradiation of liquid media with precursors, ultrathin branched nanowires of CdS were prepared in one step. The hierarchical nanowires were as thin as just 24 nm in diameter, which makes them

the thinnest hierarchical CdS nanowires ever reported. In parallel, hollow CdS nanoboxes were prepared through the synergistic combination of cation exchange and chemical etching and demonstrated the smallest dimensions reported so far, while also having the high-energy {100} surface as exposed facets. Both the novel nanostructures of CdS, ultrathin branched CdS nanowires and hollow quasi-monocrysstal CdS nanoboxes with high-energy facets, have never been reported before. As first tests, both nanostructures have demonstrated promise as photocatalysts, which is explained by their unique morphology, larch surface area, and exposed facets. Two research papers were published on the obtained results.

3) Biomorphous SiC ceramics with morphology and structure inherited from oak-cork precursor were prepared and studied. The elaborated morphology permits to prepare such ceramics with complex shapes and for various applications. A research paper was published on the obtained results.

4) Based on CdS and CdO nanoflakes, we prepared new gas sensors with high sensitivity and selectivity towards such gases as isopropanol and diethyl ether, which was found to be due to unique morphology or crystallite orientation inside such nanoflakes and due to their surface groups. Gas sensors based on ZnO and $SnO_2$ nanomaterials are currently being prepared. As outcome, two manuscripts have been submitted to journals.

5) A universal one-pot strategy was developed to produce various ZnO and doped ZnO nanocrystals with very small sizes below 10 nm and uniform size distribution. The novel technique, which is based on solution reactions, was shown to be easily scaled up and produce various nanocrystals of conducting metal oxide that, upon drying and re-dispersion in a new solvent, can be efficiently used as inks for spin-coating or printing devises. A research journal paper was published.

6) Luminescent carbon dots were prepared via a hydrothermal approach. For the first time, such materials demonstrate controllable emission, which was achieved via their surface engineering. The photoluminescence of such carbon dots was either excitation-dependent or independent, making them very promising novel nanomaterials for various applications. Multi-color composites of the carbon dots with polymers were prepared, which exhibited blue, green and even white luminescence. The results led to a paper published in a journal.

The project also succeeded in a number of knowledge-transfer activities that involved both the fellow and host group members, such as: delivery of research seminars, research training on nanomaterial preparation via laser ablation, and daily supervision of PhD students and postdocs in the lab. Finally, the fellow was involved in designing and demonstrations of experiments to the public during the LightFest and at Aston University open days.