Abstract

The present thesis summarized my research activity with direct applicability in the field of industrial chemistry. The work is organized in six chapters. First chapter is a brief description of my career path and research activity, the next four chapters presents the main achievements in: micropatterning of glass, thin films deposition on PECVD (Plasma Enhanced Chemical Vapor Deposition) reactors, self-assembled nanoparticles and drug screening on microfluidic platforms. The last chapter presents the direction of my future research.

Chapter 1. **Scientific and professional achievements**. My research activity was developed at the interface between different research fields. My background is in mechanical engineering, having a strong knowledge in electrical engineering (early years as engineer were spend in a semiconductor company). As a result, my PhD thesis was at the interface between electrical and mechanical field – Micro-Electro-Mechanical Systems (MEMS)- and, I may say that, I was one of the "pioneers" of this field in Romania. After completing post-doctoral program, in one of the high ranked universities (Nanyang Technological University), I joined Institute of Bioengineering and Nanotechnology, Singapore being one of the founders of the institute, trying to apply electro-mechanical knowledge for chemical and biological applications. Between 2017-2019, I helped prof. Luke Lee to setup a research institute targeting biomedical research (BIGHEART). From 2019, I returned in Romania at IMT Bucharest. The figures of merit in SCOPUS are: 2505 citations/130articles, H-index 31.

Chapter 2: **Micropatterning of glass**. The chapter presents the contribution of the author to one of the main technologies for the fabrication of the glass microfluidic chips: wet etching of glass. The main challenges in the field glass were related to finding a proper masking layer as well establishing a correct etching solution. The contributions of the author are related to the influence that the residual stress of the masking layer and the hydrophobicity of the mask surface have on the wet etching of glass. Few masking layers were proposed for deep wet etching of glasses such as: low stress amorphous Si, amorphous Si/amorphous SiC or Cr/Au/photoresist. The solutions were further used for the fabrication of microfluidic devices and are currently used in MEMS foundry. There is a good citation record for the published papers.

Chapter 3: PECVD thin film depositions. The chapter presents contribution of the author for the residual stress control in thin films deposition on PECVD reactors and few MEMS applications developed based on this technology. Main achievements are related to: fabrication of low stress silicon nitride layers with high deposition rate, deposition of think layers of amorphous Si and the use of amorphous SiC layers in bioapplications. The results were published in relevant journals in the field and were strongly advertise by the producer of the PECVD equipment.

Chapter 4: Self-assembled nanoparticles. The chapter presents9 the using of microfluidic hydrodynamic flow focusing for enabling an accurate control of self-assembling nanoparticles with a special focus on DNA compaction using microfluidics methods). Two original approaches in DNA compaction was developed. The first method is based on rapid change of solvent quality. A mixture of surfactant and DNA dispersed in 35% ethanol is focused between two streams of pure water in a microfluidic channel. As a result, a rapid change of solvent quality takes place in the central stream, and the surfactant-bound DNA molecules undergo a fast coil-globule transition. By adjusting the concentrations of DNA and surfactant, fine-tuning of the nanoparticle size – down to a hydrodynamic diameter of 70nm. The second method relied on the controlled diffusive mixing of surfactant and DNA solutions through a water stream of tunable width. Using this method, the smallest nanoparticles achieved were about 30 nm- hydrodynamic diameter, meaning that most of them contained a single DNA molecule. The results were published in leading journals in the field such as: Chemistry of Materials or Analytical Chemistry.

Chapter 5: Cell culture models for drug screening. 'Organ-on-a chip" models have gathered great attention since they allow recapitulation of *in vivo* situation. The chapter focus on the contribution of the author for developing a liver model – "constrained spheroid"- for static and dynamic cell culture. It was shown that the perfusion incubator-chip system can enhance and maintain primary rat hepatocytes differentiated function and metabolic function for extended period of time. The validation of the system as an acute and chronic drug testing platform was performed using two model drugs: diclofenac and acetaminophen. A microfluidic platform ("Fish & Chips'), which allows for drug perfusion studies on Zebra fish embryo is also presented. The results were published in leading journals in the field such as: Biomaterials or Lab on a chip.

Chapter 6: Future plans. My research plan for the next five year will approach mainly subjects related to: "Microfluidic nanofactories", cell culture for drug screening, liquid biopsy, Point-of care devices, e-skin.