Title: Implantable Nanofluidic Membrane and Smart Electronic System for Drug Release Control

Abstract: The work presented in this dissertation is the result of the theoretical and experimental research conducted in the field of nanomedicine and personalized health care for the jointed academic program between the Politecnico di Torino, Turin, Italy, and the Methodist Hospital Research Institute (HMRI), Houston, Texas.

The dissertation is focused on the design and development of a silicon nanofluidic membrane for ultra-low power electrostatic control of drugs and analyte elution remotely controllable by wireless communication in the field of the Nanomedicine and Personalized Health-Care. More specifically, the study is focused on tightly controlling the diffusion regimes of charged molecules through nanochannels at the nanoscale by using an electrostatic electric field. Taking advantages from their nanometric dimension, therapeutics flowing through nanochannels can be manipulated by acting on some aspects of the drug delivery system, such as dimensions and polarity of the nanochannels, and the ionic strength of the solution, among others. The significant nanotechnological advantage of the fluidic membrane resides in the independent linear flow of the drug from the concentration gradient between the molecules reservoir and the external regions. In this work, the development of the amorphous silicon carbide (a-SiC) coated solid-state nanofluidic membrane that achieved reproducible and tunable control of the drug release via electrostatic gating was discussed. Firstly, the nanofluidic design and fabrication were illustrated and investigated utilizing visual examination, such as Focus Ion Beam Microscopy, and Scanning Electron Microscopy Investigation, and mechanical investigation, such as nitrogen gas test measurements. Then, a study for the evaluation of the corrosion rate of the a-SiC membrane in the simulated implantation condition to simulate body-fluid interaction was discussed. Electrical performances were investigated with an electrochemical analysis using two different electrolyte solutions in various concentrations, i.e., potassium chloride (KCl) and phosphate buffer saline (PBS). Then, the modulation of the release rate of five medical relevant molecules are presented is reported. The results demonstrated that it is possible to effectively control the rate of the molecules release by the application of an electric field. Those results lead to the design of an electronic board that can remotely control the charged therapeutics via Bluetooth Low Energy. This new device will enable the real-time remote control over released dosage of the therapeutics, leading to a new platform for personalized medicine.

Keywords: Drug Delivery Nanofluidic Membrane, Nano-Electrofluidics, Silicon Nanochannel Membrane, Remote Control for Personalized Medicine, Chronotherapy.