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XXXIV Cycle

Implantable Nanotechnologies for Biomedical Therapeutic Applications

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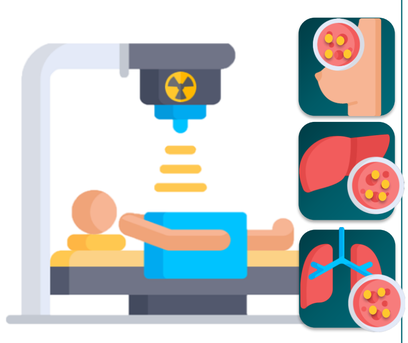
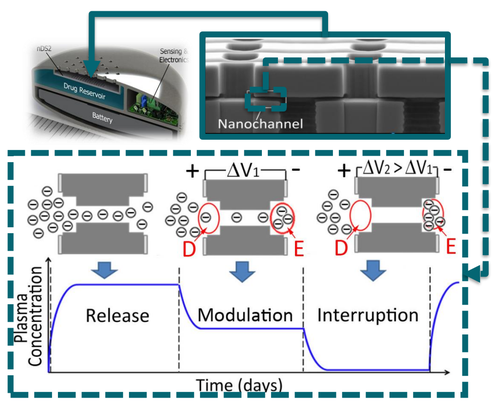
Research context and motivation

- The contribution of **Electronics Engineering** in **Nanomedicine** enables the highly efficient development of advanced medical devices and smart technologies to treat life-threatening disorders more effectively. Due to the unique properties at the nanoscale, implantable nanoelectronics devices allow the drug delivery at the target site, revolutionizing the conventional way to perform clinical practices.

1 The first context investigated is the use of **Gold Nanoparticles (GNPs)** at clinically feasible concentrations as effective radiosensitizers in solid tumors. The motivation can be found considering how often radiotherapy fails to fully eradicate tumors, due to dose limitations and radiation resistance. Electronic properties of GNPs enhance radiation effects via *physical, chemical* and *biological* interaction with ionizing radiation.



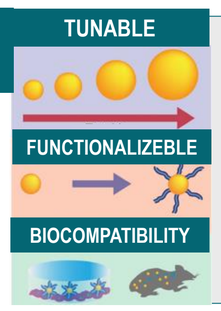


2 The second context investigated is the use of **electrostatically gated nanochannels (nCh)** for drug delivery in implantable medical devices for chronotherapeutics. The purpose is to overcome any limitations of the traditional therapeutics administration through fluidicFET-based devices, maintaining drug levels in a therapeutic window, guiding higher drug concentrations in targeted areas, and controlling externally the delivery rate.

Addressed research problems

- Nanomedicine is continually progressing at a fast pace, however significant challenges (biological, manufacturing, safety, etc) still exist in promoting these platforms into clinically feasible therapies. For the two investigated contexts:

1

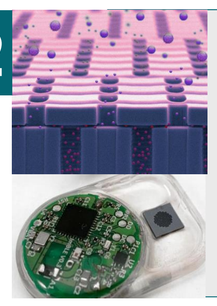


a) Predict/determine the **biodistribution** of GNPs inside the tumor;

b) Functionalize GNPs to ensure complete **cellular uptake** and **colloidal stability**;

c) Avoid possible long-term **toxicity**: tailoring GNPs properties to enable renal clearance;

2



a) The external electric field applied by the gate electrode modulates the charge carrier density in the nCh. However, to improve the performance of the device, a better understanding of the **transport phenomena** in the nCh is required;

b) Significant **driving voltage applied** to control flow could interfere with the local environment;

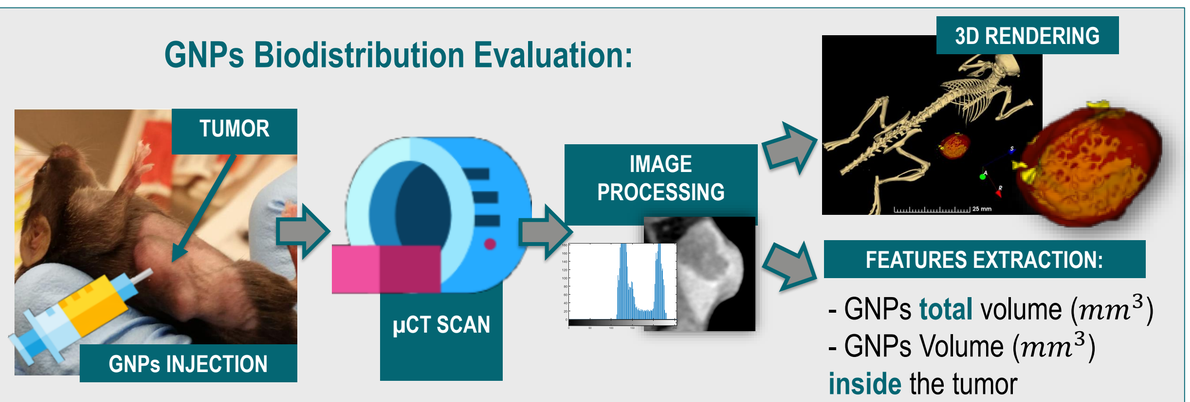
Novel contribution

1 **Image processing** and 3D reconstruction of X-ray computed tomography (CT) to evaluate the GNPs biodistribution in the Lewis lung solid tumor growth in old female C57/BL6 mice, tuning size, coating and concentration of the injected solution.

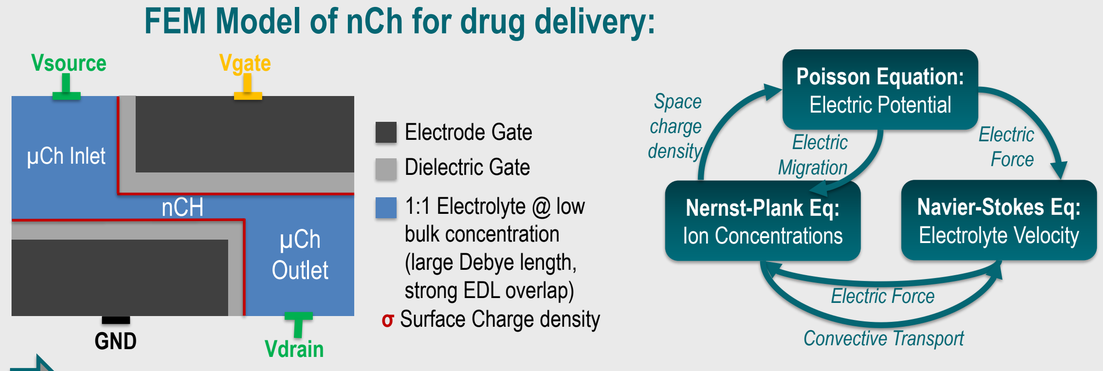
2 **FEM modeling** to simulate the tuning of the ionic current through the nCh of the nanofluidicFET-based devices for drug delivery, via electrostatic gating.

Adopted methodologies

1 **GNPs Biodistribution Evaluation:**



2 **FEM Model of nCh for drug delivery:**



Future work

1
- **Tuning the variables** of the design of GNPs to obtain percentage distribution inside the tumor > 90%;
- **Animals** laboratory training;
- **Radiation** in vivo experiments;

2
- **Add dynamic model of the surface charge density** to take into account the site binding phenomena and the pH of the solution;
- **Validate** the model with analitical solutions or other prevoius pubblications;
- **Validate** the model with experimental trials;

External Training Activities

- Workshop: Product Development for Medical Devices and Biopharmaceuticals, EPFL, Lausanne (5/11/2018, 9 Hours)
- Congresso Regionale Regione Piemonte, Scienza ortottica: dalla ricerca scientifica alla pratica clinica (17/11/2018, 4 Hours)
- Trasferimento Tecnologico e Valorizzazione dei risultati della ricerca scientifica, I3P, Torino (21/11/2018, 6 Hours)
- International Volunteering: Prime 2019, 15th Conference on PhD Research in Microelectronics and Electronics (15/7/2019)

Acknowledgment

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Submitted and published works

- Terracciano, R., Demarchi, D., Ruo Roch, M., Aiassa, S., Pagana, G., ‘’*Recent advances in Nanoparticle-based structures to fight Cancer* ‘’, Journal of Nanoscience and Nanotechnology, 2019, **(Submitted)**
- Terracciano, R., Sanginario, A., Puleo, L., Demarchi, D., ‘’Live Demonstration: Smart Glasses-Based Portable System for Pattern-Reversal Visual Evoked Potential Clinical Evaluations‘’, IEEE Biomedical Circuits and Systems Conference (BioCAS), 2019, **(Accepted)**
- Terracciano, R., Sanginario, A., Barbero, S., Putignano, D., Canavese, L. and Demarchi, D., ‘’*Pattern-reversal visual evoked potential on smart glasses*’’, IEEE journal of biomedical and health informatics, 2019, pp. 1-9, **(Published)**
- Aiassa, S., Grassi, F., Terracciano, R., Carrara, S., Demarchi, D., ‘’*Live Demonstration: Quasi-Digital Portable Pen to Monitor Anaesthetics Delivery*’’, IEEE Biomedical Circuits and Systems Conference (BioCAS), 2019, **(Accepted)**
- Sapienza, S., Motto Ros, P., Fernandez Guzman, D.A., Rossi, F., Terracciano, R., Cordedda, E. and Demarchi, D., ‘’*On-line event-driven hand gesture recognition based on surface electromyographic signals*’’, 2018 IEEE International Symposium on Circuits and Systems (ISCAS) , 2018, pp. 1-5, **(Published)**

List of attended classes

• 01SCRIU – High-throughput biological data analysis	(30/10/2018, 4 CFU)
• 01QSXRU – The measurement of electrical impedance	(05/03/2019, 2 CFU)
• 01SFURV – Programmazione scientifica avanzata in Matlab	(27/03/2019, 4 CFU)
• 01QRNRV – Electromagnetic dosimetry in MRI	(17/04/2019, 4 CFU)
• 03SGVRV – Entrepreneurship and start-up creation from UR	(09/05/2019, 8 CFU)
• 01RGGRV – Telemedicine and Distributed Healthcare	(27/05/2019, 4 CFU)
• 01TFGKG – Oxide Electronics: from conventional to MC	(04/07/2019, 4 CFU)
• 01TGTKI – Physical Chemistry of Materials for Nanotechnologies	(04/09/2019, 7 CFU)

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