3D-Printed *In Vitro* Tumor Models for Micro-/Nano-robots

Smart Technologies for Tumor Therapy
DKFZ Dresden
Prof. Dr. Tian Qiu

Preferred Course of Study/Expertise of Candidate
A Master degree in Biophysics, Biology, Biomedical Engineering, Tissue Engineering, Cell Biology or relevant fields is required. Interest or experience in the fields of microdevices, microfluidics, organ-on-a-chip, soft biomaterials, rheology, biomechanics, medical physics is preferred.

Project summary
The recent technology advancements of micro-/nano-system engineering and robotics open up new possibilities for the next-generation of surgical robots: **wireless micro-/nano-robots**, which can be controlled to navigate in the human body and may be used for various medical applications such as drug delivery, *in vivo* sensing and stimulation. The team succeeded in developing the first soft micro-robot that can swim in biological non-Newtonian fluids by reciprocal motion [1], and the first nano-robots that can penetrate real tissue – *i.e.* the vitreous of the porcine eye [2].

The group has an exciting new project called "**VIBEBOT**" (Vibrational Micro-robots in Viscoelastic Biological Tissues, https://cordis.europa.eu/project/id/101041975) funded by the European Research Council (ERC) Starting Grant. The overall goal is to build the first micro-sized robot that can actively propel and wirelessly sense in deep biological tissues. We will develop innovative localization/imaging methods at small scale, *e.g.* using magnetic field, ultrasound, or radiation, to guide micro-robots to the targeted tumor location. VIBEBOT reveals enormous potential for future medicine, such as targeted drug delivery and minimally-invasive surgery for tumor therapy.

The Ph.D. project will be closely related to the above-mentioned ERC project. The aim of the project is to build an ***in vitro* tumor model** that realistically represents the mechanical and physiological properties of an *in vivo* solid tumor. Two approaches will be investigated to build the physical model: 1) 2-photon lithography printing micro-scaffolds and seeding cancer cells; 2) In-situ 3D printing of cancer cells in an extracellular matrix (ECM) mimicking hydrogels. Multiple-cell type glioblastoma tumor spheroids will be initially focused on. Blood-brain-barriers (BBB) will also be constructed. To validate the correctness of the mechanical and physiological properties of the models, assorted micro-mechanical testing, and imaging methods will be applied. After validation, the models will serve as testing environments to optimize the wireless micro-robots [3] and micro-devices [4] developed by the engineering team in the same group.

Desired qualifications
The selected PhD candidate will work at the **DKFZ Site Dresden**. In Dresden, the DKFZ teams up with the Excellent University **TU Dresden**, aiming at innovative technology-based approaches for tumor diagnostics and therapy. The project is going to be carried out in the new Division “Smart Technologies for Tumor Therapy” led by Prof. Tian Qiu, affiliated also both Faculty of Medicine and Faculty of Electrical and Computer Engineering, TU Dresden. The group offers an attractive working environment with interdisciplinary fields including biology, material science, engineering, artificial intelligence, as well as computational and medical physics. It is an international group that consists of current members from 6 different nationalities.

A Master degree in Biophysics, Biology, Biomedical Engineering, Tissue Engineering, Cell Biology or relevant fields is required. Interest or experience in the fields of microdevices, microfluidics, organ-on-a-chip, soft biomaterials, rheology, biomechanics, medical physics is preferred. The suitable candidate should be self-motivated and possess excellent English skills. Open mindedness towards discussing novel ideas and the flexibility to apply various experimental methods (potentially combining different areas of expertise) are favorable.

Keywords
tissue engineering, organoid, 3D printing, cell culture, organ on a chip, micro-/nano-technology, robotics, control

References
[1] Qiu, T., Lee, T. C., Mark, A. G., Morozov, K. I., Münster, R., Mierka, O., Turek, S., Leshansky, A., Fischer, P. (2014). Swimming by reciprocal motion at low Reynolds number. **Nature communications**, 5(1), 5119.
[2] Wu, Z., Troll, J., Jeong, H. H., Wei, Q., Stang, M., Ziemssen, F., Wang, Z., Dong, M., Schnichels, S., Qiu, T., Fischer, P. (2018). A swarm of slippery micropropellers penetrates the vitreous body of the eye. **Science advances**, 4(11), eaat4388.
[3] Ma, Z., Melde, K., Athanassiadis, A. G., Schau, M., Richter, H., Qiu, T., Fischer, P. (2020). Spatial ultrasound modulation by digitally controlling microbubble arrays. **Nature communications**, 11(1), 4537
[4] Fischer, F., Gletter, C., Jeong, M., Qiu, T. (2024). Magneto-oscillatory localization for small-scale robots**. npj Robotics**, 2, 1.