Stimuli-responsive Mesoporous Silica Nanoparticles for Applications in Cancer Theranostics

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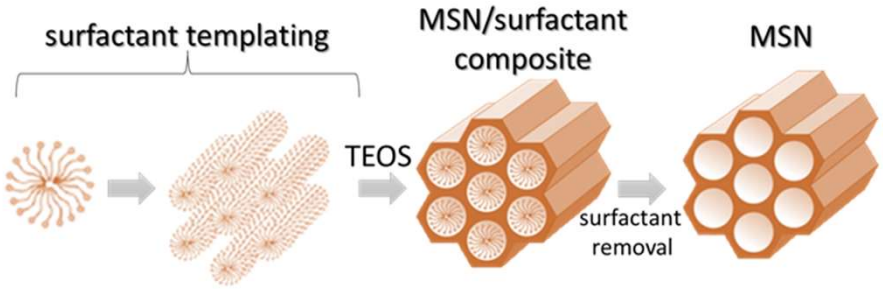
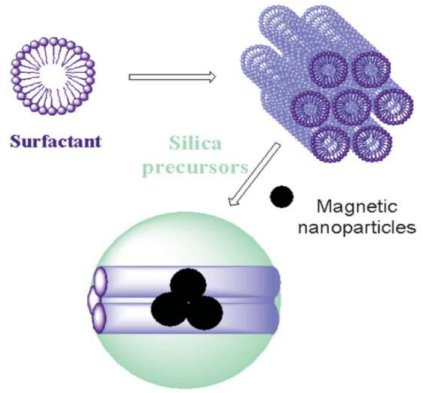
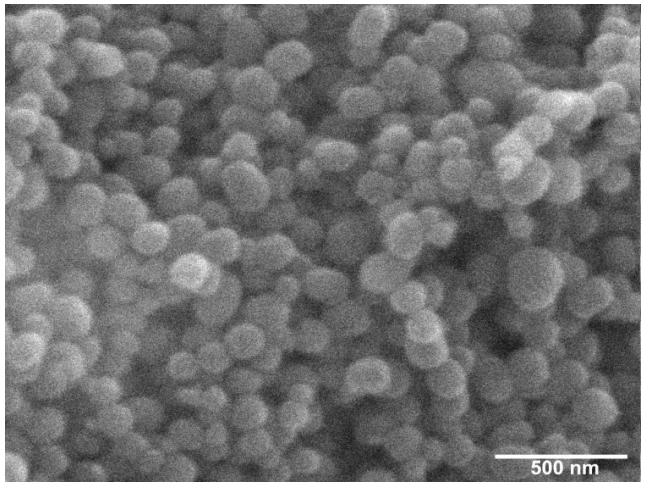
Mesoporous Silica Nanoparticles (MSN)

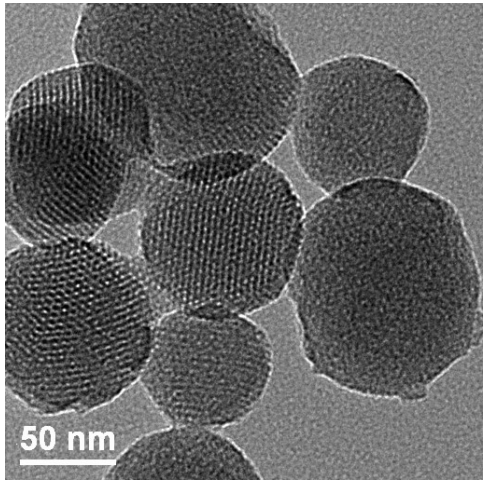


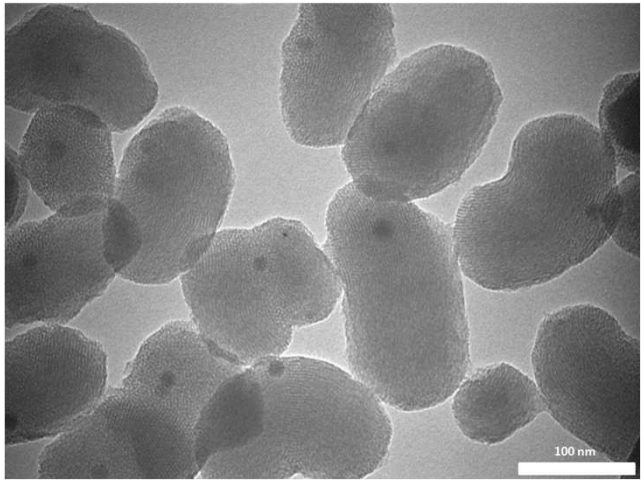
Magnetic mesoporous Silica Nanoparticles (MMSN)





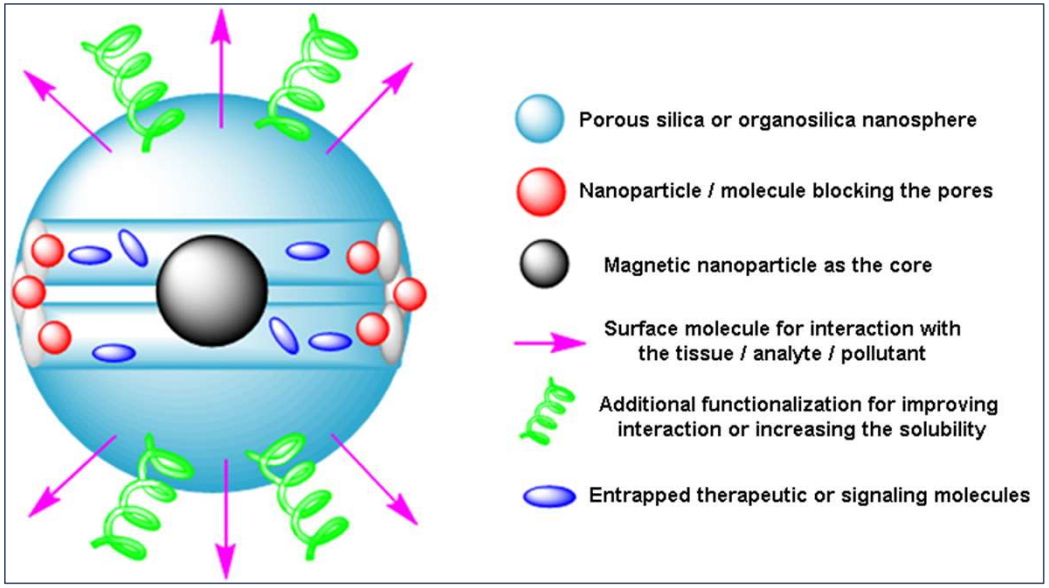
Scanning electron micrograph (SEM)

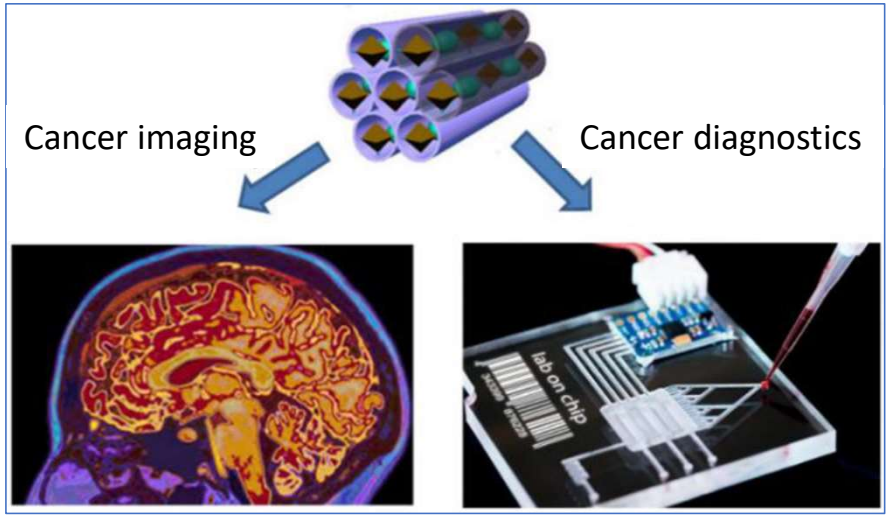




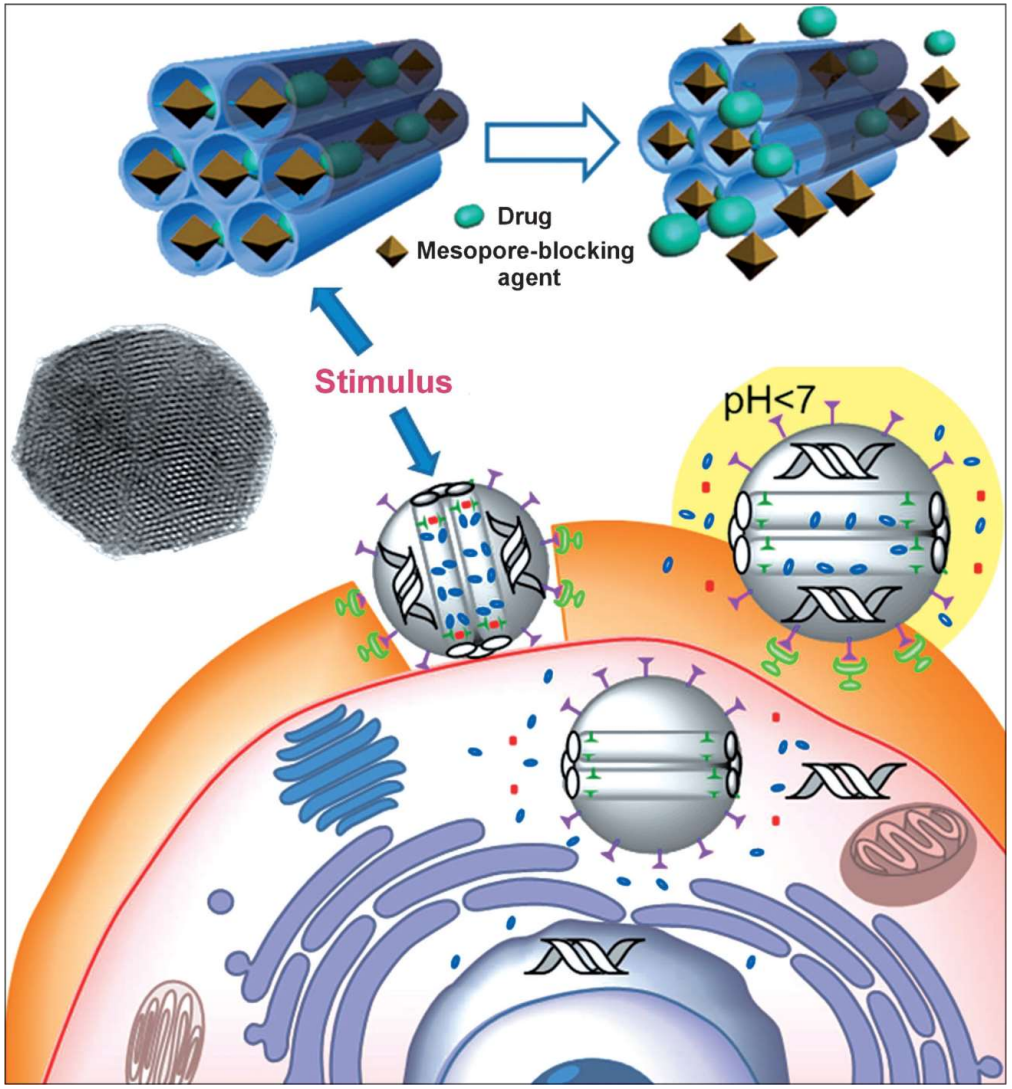
Transmission electron micrographs (TEM)

Research interests

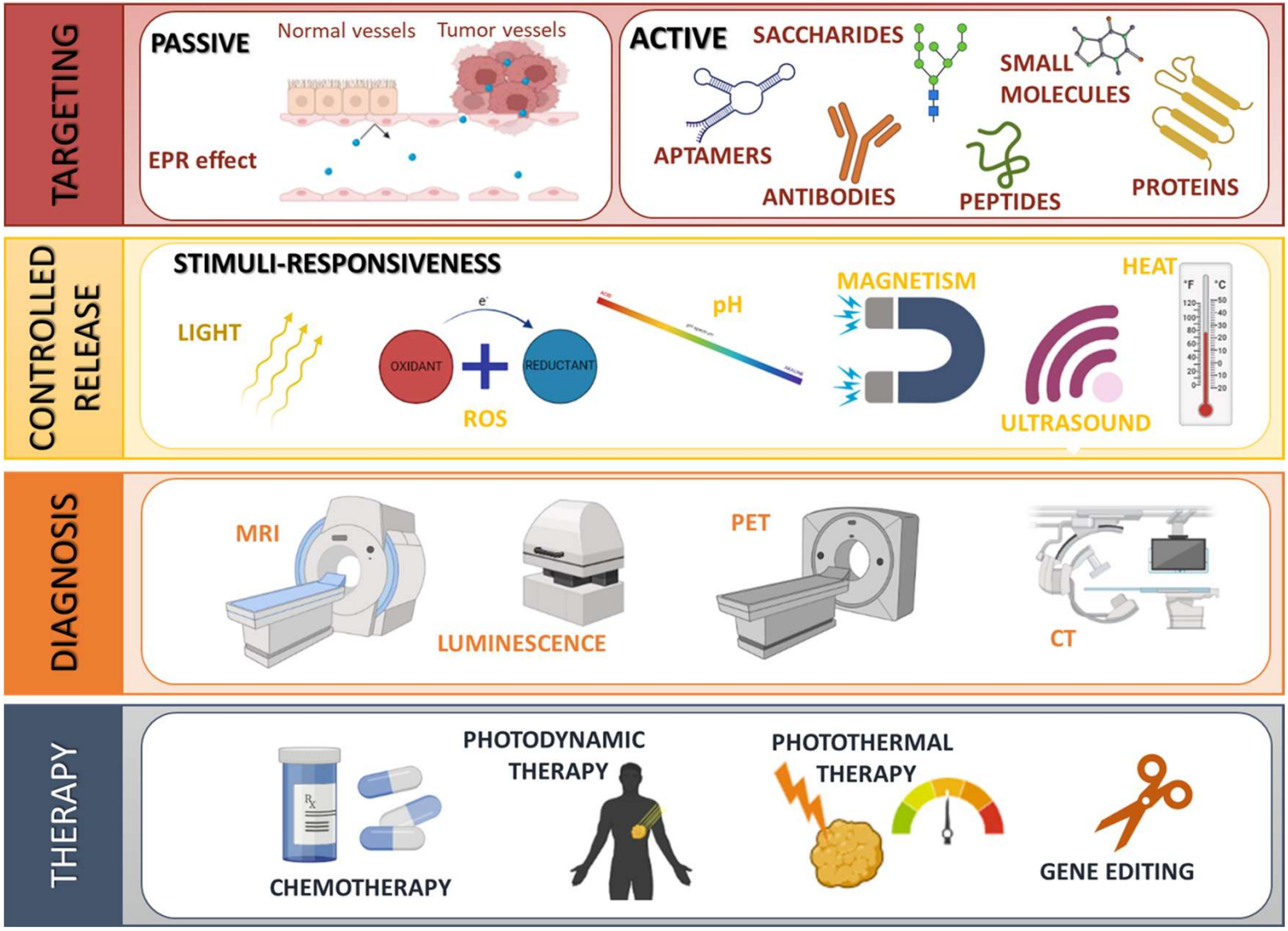




Targeted Treatment of Cancer



Multifunctional anticancer opportunities of MSN



Advanced mesoporous silica nanocarriers in cancer theranostics and gene editing applications, *Journal of Controlled Release* 337 (2021) 193-211.

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CNRS, Montpellier, France
Dr Jean-Olivier Durand

Science Fund of the Republic of Serbia

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GA #952259

WIDESPREAD-05-2020: Twinning

such as limited bioactivity, unfavorable mechanical stiffness, poor dimension controllability, etc. In this research, we developed water-soluble polymer(e.g., polyvinyl alcohol, hyaluronic acid and gelatin)-based negatively-charged hydrogel microfibers with enhanced bioactivity and adjustable mechanical properties. In order to increase dimensional controllability of hydrogel microfibers, we homogenized these microfibers and precipitated them by adding cationic polyelectrolyte, leading to the entangled hydrogel microfibrillar network with microscale porosity. Furthermore, because those fibers were made by combination with natural polymers, the hydrogel microfibrillar network was degradable by enzyme treatment (>95% by hydrolase such as collagenase or hyaluronidase). Also following the degree of crosslinking, the degradability and size of entangled hydrogel microfibrillar network were well modulated by controlling their composition and fiber diameters. Finally, we demonstrated that these colloidal hydrogel microfibers mixed with cells could be patterned by using a conventional 3D printer, suggesting that resultant hydrogel microfiber scaffolds are suitable for various types of 3-D cell cultures.

4:30 PM SB02.12.03
Late News: Ultra-Tough and Stiff Ionogels by *In Situ* Phase Separation Meixiang Wang and Michael Dickey; North Carolina State University, United States

Ionogels are compelling materials for energy storage devices, ionotronics, and actuators due to their excellent ionic conductivity, thermal and electrochemical stability and nonvolatility. However, most existing ionogels suffer from low strength and toughness. Here, we report a simple one-step method to achieve ultra-tough and stretchable ionogels by randomly copolymerizing two common monomers in ionic liquid. Copolymerization leads to a single covalent network with controllable polymer- and solvent-rich phases that form in situ due to the phase behavior of the polymer in ionic liquid. The polymer-rich phase forms hydrogen bonds that dissipate energy and thereby toughen the ionogel during extension, while the solvent-rich phase remains elastic to enable large strain. The copolymer ionogels composed of acrylamide and acrylic acid exhibit extraordinary mechanical properties, including fracture strength (12.6 MPa), fracture energy (~24 kJ m-2), and Young's modulus (46.5 MPa), setting new records among reported ionogels. The tough ionogels are highly stretchable (~600% strain) and possess good self-recovery, as well as excellent self-healing and shape-memory properties. This concept extends to other monomers and ionic liquids, which offers a promising and general way to tune microstructure in situ during one-step polymerization that solves the longstanding mechanical challenges in ionogels.

SYMPOSIUM SB03

Transformative Nanostructures with Therapeutic and Diagnostic Modalities
November 30 - December 7, 2021

Symposium Organizers
Jennifer Dionne, Stanford University
Isabel Gessner, Harvard Medical School-Massachusetts General Hospital
Gerardo Goya, University of Zaragoza
Sanjay Mathur, University of Cologne

* Invited Paper

SESSION SB03.01: Transformative Nanostructures with Therapeutic and Diagnostic Modalities I
Session Chair: Polina Anikeeva
Tuesday Morning, November 30, 2021
Sheraton, 2nd Floor, Independence East

10:30 AM *SB03.01.01
Controlled Delivery Technologies for Modulating the Immune System to Engineer Potent and Durable Vaccines Eric A. Appel; Stanford University, United States

Vaccines can take one of several forms, but those based on subunit antigens (representative subunits of the pathogen for which immunity is desired) offer the greatest safety profile and scalability, but generally elicit weaker and less durable immune responses. Failure to elicit a sufficiently strong response likely arises from inappropriate temporal control over antigen/adjuvant presentation and immune cell activation. Either short-term presentation of these signals, or misalignment of their presentation along different timelines, results in poor affinity maturation of antibodies and poor immune memory responses. When considering the iterative selection process occurring during somatic hypermutation and antibody affinity maturation in B lymphocytes, it is intuitive that prolonged lymphocyte activation and antigen exposure would lead to the generation of higher-affinity antibodies. Moreover, the immune system is highly spatially organized and so spatiotemporal control over vaccine exposure is crucial to potent and safe responses. In this work we will discuss novel technologies for improving the spatiotemporal presentation of vaccine components to the immune system. In particular we will describe an injectable hydrogel platform providing unique drug delivery capabilities for the long-term co-delivery of antigen and adjuvant in subunit vaccines and discuss the impact of prolonged vaccine delivery on humoral immune responses. We demonstrate that prolonged hydrogel-based immunizations greatly enhance the magnitude and duration of antibody responses, enhance and prolong germinal responses, and lead to 1000-fold enhancement in antibody affinity maturation when compared to the same vaccine delivered in bolus. These advanced materials technologies, therefore, have the potential to provide

Mexico; [4]CIATEJ, Mexico

Design of theranostic nanocomplex has gained a lot of attention because its capability for simultaneous imaging, detection and therapy. In particular, high selectivity nanocomplex for photodynamic therapy and drug delivery are important tools to fight the cancer problem. Here, we report recent results on the design of theranostic complex based on the use of upconversion nanoparticles (UCNP) which convert near infrared (NIR) excitation at 970 nm into blue, green, red and NIR emission tuned with the lanthanide doping ion. Such nanoparticles are ideal for overpassing the limited penetration depth of conventional photodynamic therapy (PDT), also useful for imaging and detection. Green and red emissions were obtained with the introduction of Er^{3+} ion. The green and red emission is used as an excitation source for zinc phtalocyanine (ZnPc), a photosensitizer (PS) bounded to the surface of UCNP. PS transfers energy to molecular oxygen in the surroundings to produce reactive oxygen species (ROS) able to induce death of breast cancer cells (BCC). Selectivity was obtained by the conjugation with Trastuzumab (Tras), a specific monoclonal antibody for selective detection and treatment of HER2-overexpresing malignant BCC. With the use of nanocomplex UCNP-ZnPC-Tras, was observed selective tracking of SKBR-3 HER2+ BCC by using a confocal microscope and reducing cells viability to 80% upon 200mg/ml load and 5 minutes of irradiation. Furthermore, PS was replaced for a photocatalytic TiO_2/ZrO_2 shell which is excited with blue light coming from Tm^{3+} ions enhancing the ROS production and then killing cancer cells up to 88%. In this case, emission band at 801 nm was used for tracking cells at deep tissue. Indeed, we report the fabrication of inmunoliposomes nanocomplex loaded with UCNP, PS for PDT and drugs for chemotherapy. Results shows a combined chemo-photodynamic synergistic effect killing cells up to 80% after 10mM load and 5 minutes of irradiation. The specificity of our nanocomplex was achieved by conjugating a newly discovered anti-HER2 peptide screened from a phage display peptide library. The high selectivity of the peptide-conjugated was confirmed by confocal imaging of SKBR-3 (HER2-positive) and MCF-7 (HER2-negative) breast cancer cell lines, illustrating its target-specific nature. Results suggest great potential for multifunctional theranostic nanocomplex for detection, imaging and therapy of cancer.

We acknowledge financial support from UDLSB and CONACYT through grant 259192.

8:15 AM SB03.05.10
Stimuli-Responsive Mesoporous Silica Nanoparticles for Applications in Cancer Theranostics Nikola Knezevic, Minja Mladenovic, Mirjana Mundzic and Aleksandra Pavlovic; University of Novi Sad, Serbia

Mesoporous silica nanoparticles (MSN) exhibit highly beneficial features for devising nanosystems applicable in cancer therapy, imaging, or diagnostics. The high surface area of MSN, which can be easily postsynthetically functionalized with different organosilanes, in addition to their structured porosity available for loading cargo molecules, allows plethora of opportunities for devising multifunctional and multipurpose nanostructures.
In this context, our research focuses on devising MSN-based cancer theranostics, containing different modalities for targeting specific cancer microenvironment, and the capabilities for delivering cargo therapeutic molecules upon exposure to the specific conditions of this environment, such as tissue acidosis or elevated concentration of glutathione and other cancer-related biomolecules. Thus, specific surface modification and controlling the release process of therapeutic molecules enables utilization of MSNs as unique facilitators toward enhancing the efficacy and precision of cancer treatment, imaging and sensing.

SYMPOSIUM SB04

Materials and Algorithms for Neuromorphic Computing and Adaptive Bio-Interfacing, Sensing and Actuation
November 30 - December 7, 2021

Symposium Organizers
Paschalis Gkoupidenis, Max Planck Institute
Priyadarshini Panda, Yale University
Francesca Santoro, Istituto Italiano di Tecnologia
Yoeri van de Burgt, Technische Universiteit Eindhoven

Symposium Support
Bronze
Neuromorphic Computing and Engineering (NCE) | IOP Publishing

* Invited Paper

SESSION SB04.01: Materials and Devices for Neuromorphic Computing
Session Chair: Paschalis Gkoupidenis
Tuesday Morning, November 30, 2021
Sheraton, 2nd Floor, Liberty B

10:30 AM *SB04.01.01
Using New Materials for Brain-Like Computing—From Fundamental Mechanisms to High-Performance Devices Alberto Salleo; Stanford