Developing flexible and porous microelectronics array to control engineered cardiac patches

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The specific aim in this proposal was to:

Develop a novel multielectrode microelectronic chip for cardiac tissue engineering. The microelectronics was proposed to be porous, flexible and completely free-standing, allowing to online record the changes in action potentials, and provide electrical stimulation and triggerable control release of drugs. Later on (out of the scope of this proposal) this microelectronic chip is supposed to be integrated with 3D biomaterials to create a microelectronic cardiac patch allowing recording of cardiac cell function, electrical stimulation of the cells, and controllable, spatiotemporal release of drugs.

The developed electronic array was designed to have 64 active electrodes. The distance between the electrodes varied between distinct designs starting from 100 μm and reaching 1 mm (according to the size of the patch and the exact application). The array consisted of 56 electrodes designated for recording cellular electrical activities or for electrical stimulation, and eight electrodes for controlled release of drugs. The electronics was fabricated on sacrificial layers, which were subsequently removed, yielding free-standing, porous electronic mesh. In brief, a layer of SU-8 resist was coated on a sacrificial layer, and patterned by lithography. Next, a thin layer of gold (100-200 nm) was patterned on the resist to create the electrodes. Finally, a layer of resist was deposited and lithographically defined as the upper passivation layer on the electrodes, leaving 56 x 30/30 μm2 square electrodes for recording and electrical stimulation and 8 x 150/150 μm2 square electrodes for deposition of the electroactive polymers. The total thickness of the electronics (5-7 μm) ensured that the device is twistable and flexible, allowing transformation of the 2D mesh into a thick 3D structure after incorporation of the ECM-like scaffold material and rolling/folding, without affecting electrode performances. In addition, the successful fabrication of the porous electronic array provided enhanced flexibility, and more importantly ensured neglectable interference of the electronics within the final 3D structure