NANOSCIENCE AND MEDICINE

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Medicine has been related to many fields of knowledge, ranging from biology and chemistry until the latest advances in nanotechnology and materials science.

Nanotechnology has been a field in continue development starting in the 60's where one of their main voices of this raising area was the physics and Nobel Prize Winner Richard Feynman from CALTECH. He was convinced that the study in the microscale would have a great impact in our vision and understanding of the world and would carry unimaginable applications [1]. He was right.

By definition nanotechnology is the science that studies all the phenomenon in the micro and nano scale, from micrometers (1 meter divided in 1'000.000 equal parts) to nanometers (1 meter divided in 1.000'000.000 equal parts), just for reference the diameter of a human hair is about 50 to 100 micrometers.

To do research work in the nanoscale it is supposed to have specialized instrumentation and cutting-edge laboratories being this an important challenge in characterization and fabrication of new devices for real life applications.

Nowadays there are different paths to follow when a researcher wants to explore how nanotechnology can improve the medical field. One of them is the nanofabrication of Micro Electro Mechanical Systems (MEMS).

MEMS are devices that relate motion and sensing using microstructures and could generate electrical signals based on the external excitation. Microsensors, nanoactuators and systems (arrays of them) are also commonly called MEMS.

One important challenge in medicine is the biosensing, i.e., to detect and measure precisely pathogen agents in vitro/in vivo, precise drug delivery or to take/deliver electrical signal from/to neurons. Microelectrode Arrays (MEAs) are commonly used to these ends and have been evolved by years. MEAs can be fabricated as 2D and 3D structures using different micromachining techniques (e.g. laser) [2] and 3D printing (e.g., additive manufacture,

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stereolithography and digital light processing) applied to different metal and non-metal materials like polymers.

When experiments in vitro are desirable, culture wells can be an important approach to do measurements in body cells under controlled conditions. Those culture wells have advantages in relation to the number of measurement points which are the electrodes (Figure 1).

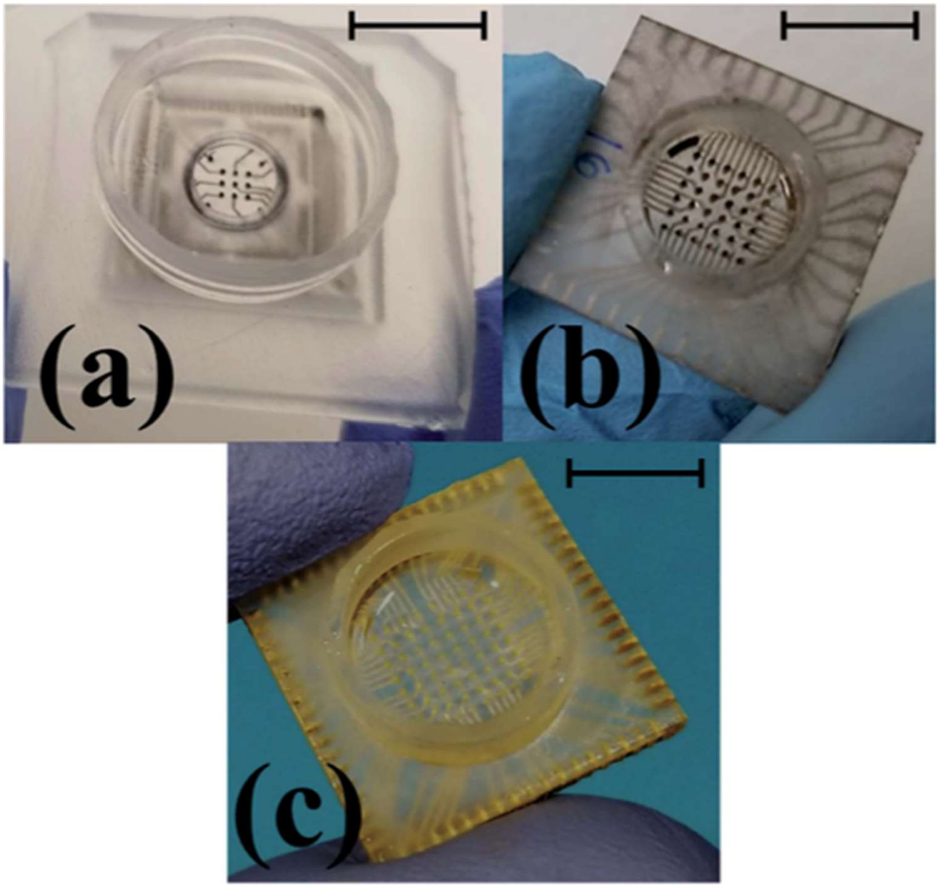

Figure 1. Optical images of different culture wells with 3x3, 6x6 and 8x8 MEAs. 10 mm scale bar. The image is reproduced with permission from [3].

Gold or platinum features are used in the microelectrodes to transport electrical signals with minimal restriction to the flow of electrical current and because of the biocompatibility of these materials [3]. Electrogenic cells can be monitored by using this MEAs, which can record and send electrical signals to the cell network.

MEAs can also be combined with other type of electrodes such as Interdigitated Electrodes (IDEs). This mixed system is useful when it is relevant to sense bacteria, diseases agents and its growing in biological fluids. The small size of electrodes allows them to be placed through microchannels transporting the fluid. Experimental findings show rapid detection of infectious agents as Escherichia coli (Gram negative) and Staphylococcus aureus (Gram positive) bacteria [4].

What happens is that IDEs are continuously measuring a variable called impedance which is the opposite to conductivity both related to the fluid content and media. Impedance peak-detection is the result of bacterial activity in the sample.

Simultaneously, MEAs record electrophysiological measurements as action potentials in the bacterial culture identifying growing. Using these techniques, the device (Figure 2) can show advantages over the traditional and expensive optical techniques.

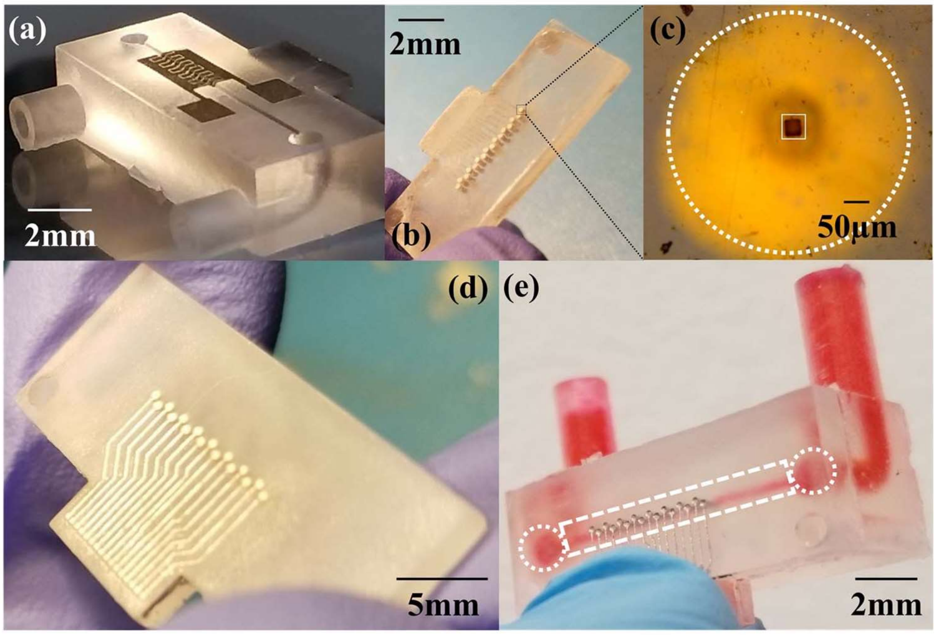

Figure 2. Optical micrograph of the biosensor using MEAs and IDEs. The image is reproduced with permission from [4]

It is important to recognize two aspects in this kind of measurements, sensitivity and selectively. Sensitivity is how fine a measurement can be, while selectively is the property of any sensor to measure what is supposed to measure. For example, if a device is trying to measure levels of sugar in the blood it could be say that the instrument is very sensitive if it can measure sugar in pretty small quantities among the mix and it is said that the instrument is highly selective when it can detect the sugar inside the mix with a high accuracy without ambiguity.

MEAs are also important features in the medicine field when they are intended to be used in monitoring signs directly in body as a wearable device.

There is one approach that deal with stretchable devices that include MEAs as electrodes. This type of devices can be used to measure biological signs directly in the skin.

The Nanobiosensors and Systems Laboratory[2] in UCF under supervision of Dr. Rajaraman has been developing an interesting research of micro serpentines (µserpentines).

One of their approaches (Figure 3) was tested in laboratory using artificial skin and it had reliable measurements in impedance over the electrodes that showed stable behavior during a determined number of cycles (strain and relaxation) making it ideal for personal health monitoring [5].

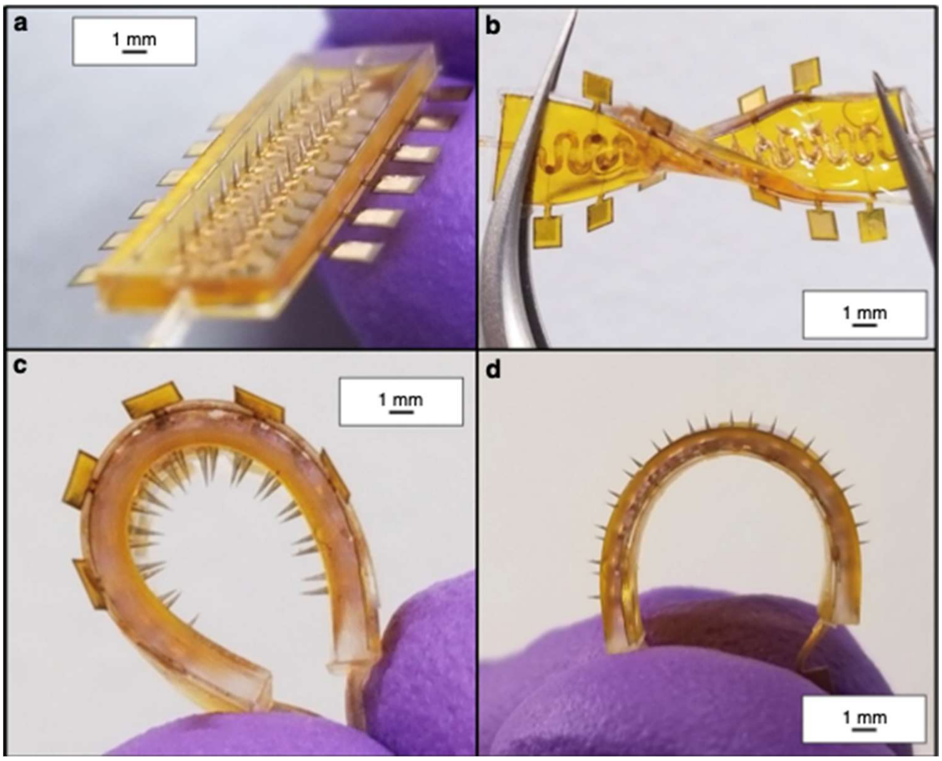

Figure 3. Optical image of microserpentine sensor device. The image is reproduced with permission from [5]

[2] http://nanoscience.ucf.edu/rajaraman/pages/group.html

It can be concluded that there is still a long way to follow in terms of research that might improve health monitoring techniques, response times and accuracy. In the vast realm of the medicine there is an allied science as nanotechnology that is giving interesting results and hopefully some of them can be viable in production beyond the laboratories and further commercialization.

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