Support information

Cell membrane electrical charge investigations by silicon nanowires incorporated field effect transistor(SiNWFET) suitable in cancer research

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MTT assay

To investigate the biocompatibility of SiNWs, we used a MTT (3-(4,5-dim ethyl thiazol – 2-yl)-2,5-dipheny l.tetra zolium bromide) assay. The sensor surface has been sterilized by autoclave before cell seeding process. The HT29 cells were seeded on SiNW surface and after 24hrs, they were detached from the substrate by trypsin and the cell culture media was added to the cell solution. In the next step, the cells were placed in the wells of a sterile 96 well micro plate with the same concentration and the MTT protocol was applied on each well. This test determines the viability of the cells based on colorimetric measurement. The reduction of yellow tetrazole to purple formazane is related to the ratio of remained live cells. Metabolic activity of the cells

depends on the density variation of this color in the HT29 cell solution. In this regard, 10µl of MTT solution with the concentration of 5 mg/µl was added to each well. The wells were incubated for 4hrs in 5% CO_2 ambient in 37^{o}C. Next, the float materials were removed from the surface of the wells and 100µl of dimethylsulfoxied was added to each well. After 20 min stirring of each well (in order to solving the formazane) the optical absorption of each cell contained well was calculated in 493 nm by micro plate reader system. The percent of viable cells versus the control well and slope variation versus absorption diagram was indicated[1]. The cell concentration gradient to absorption was calculated by the following equation

$$(\text{Absorption} = (0.0172 \times \text{Cell number}) + 94) \qquad (1)$$

Biocompatibility results of skein SiNWs

Figure S1-a presents the MTT diagram of skein SiNW structure during the interaction with HT29 cells. MTT is a useful examination showing the viability of the living species to remain alive while exposed to a given environment. The presented MTT results indicate that 90% of the adhered cells to their surface remained alive. The florescent microscope images from SW48 cancer cells which were tagged by green florescent protein (GFP) before seeding on SiNWs surface have been shown in figure S1-b. The expression of GFP (green image of the cells) is another confirmation of cell viability after culturing on SiNW structures. Trypan blue is a vital stain used to selectively colour dead tissues or cells blue. It is a diazo dye. Live cells with un affected cell membranes are not coloured. Because of cell memebrane selectivity in passing the compound through itself, in a viable cell trypan blue are not absorbed. It traverses the membrane in a dead cell. Hence, dead cells are observed as a distinctive blue colour under a microscope. In

this experiment we incubated the Human umbilical vein endothelial cells (HUVECs) with the culture media which had been held in Si nanowire arrays for more than 24hrs. After 2 days from incubation we added the trypan blue to the cultured cells and study the amount of blue cells under the microscope. Figure S1-c showed that less than 5% of the cells were coloured which is another corroboration for biocompatibility of nanowires.

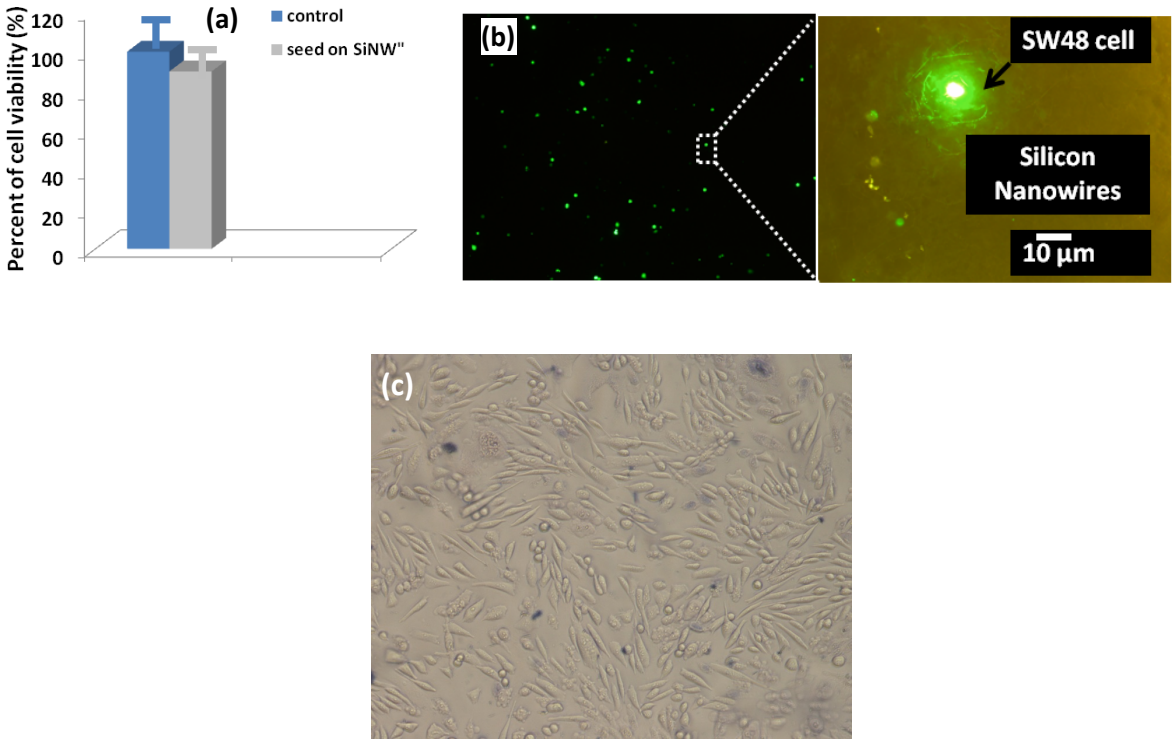


Figure S1. (a) MTT diagram of cells seeded on nanowires in comparison with control sample. b) The florescent microscope image from the SW48 cancer cells cultured on skein nanowires after 24hrs. The cells were tagged by GFP before seeding. The green color of the cells is the sign of their viability after culturing on nanowires surface. (c) Optical image from trypan blue staining assays of HUVEC cells incubated with Si nanowires for 48hrs.

viability of both HT29 and SW48 seeded cells on nanowires covered gate was tested by MTT assay after the electrical measurements in a same manner as mentioned above. The results show a well vitality (more than 94%) for the cells.

Also many parameters such as hydrophilicity would be important in the biocompatibility of SiNW surface. To investigate this effect we conducted a contact angle test to determine the wettability of the nanowires by water as seen in part (a) of figure S2. For skein SiNW surfaces, the contact angle changed from 110^{o} to 125^{o}. These values are averaged from five readings on different locations of the sample, indicating that the nanowires have super hydrophil surfaces. The outer membrane of all eukaryotic cells are hydrophil [2] which shows good adhesive interactions with hydrophilic surfaces. FTIR spectra of the skein SiNW surface is another corroboration of the hydrophilicity of such surfaces as shown in figure S2-b. The observed peaks at 1087 and 801 cm^{-1} wavenumbers, characterized as Si–O bonds [3], which improve the hydrophilic properties of nanowires. Also it would be applicable in immobilizing various biological analytes such as cells and proteins [4]. In addition, SEM images of HT29 cells seeded on SiNW surface for 24hrs (figure S2-c) corroborate that these structures are suitable to apply bioelectrical interactions with cells. The stretched morphology of the cells on the nanowires is observable in the image as their hydrophilic interaction as well as an indication for biocompatibility of these structures.

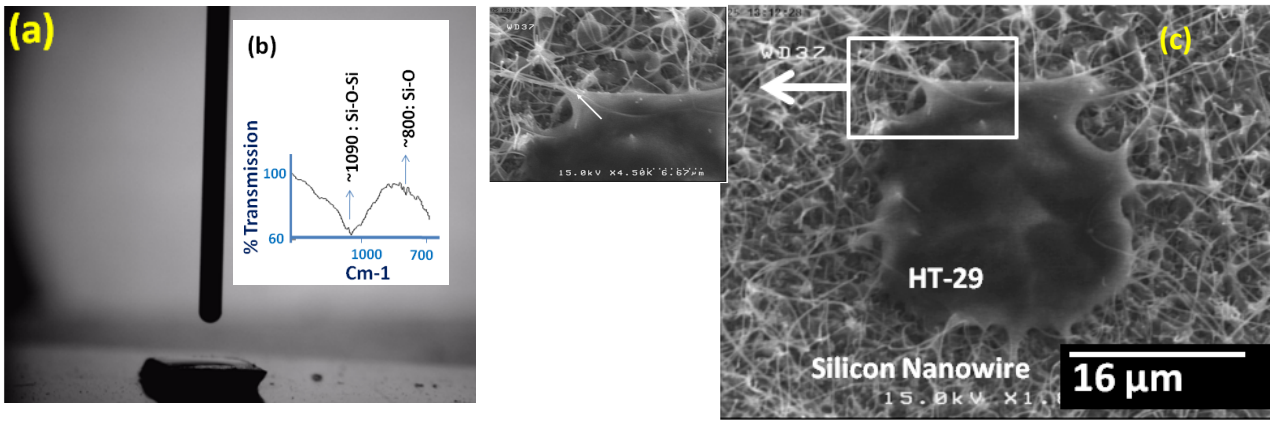


Figure S2. (a) Contact angle image of water droplet deposited on skein SiNW surface. (b) FTIR spectra of nanowires in the region in which located for oxide peaks. (c) SEM image from HT29 cancer cell cultured on the surface of skein nanowires. Stretching of the cell on the wires is the result of proper hydrophilic adhesion of the cells on this biocompatible structure.

It is worth noting that for a proper attachment of cells Extra Cellular Matrix (ECM) to a surface, shape and morphology of skein nanowires are more suitable for secreting as well as binding of specific receptors and ligands (named RGD domains) to achieve a focal adhesion (as shown in fig S2-c) in comparison with the aligned nanowires with a lower ratio of nanowire covered effective surface.

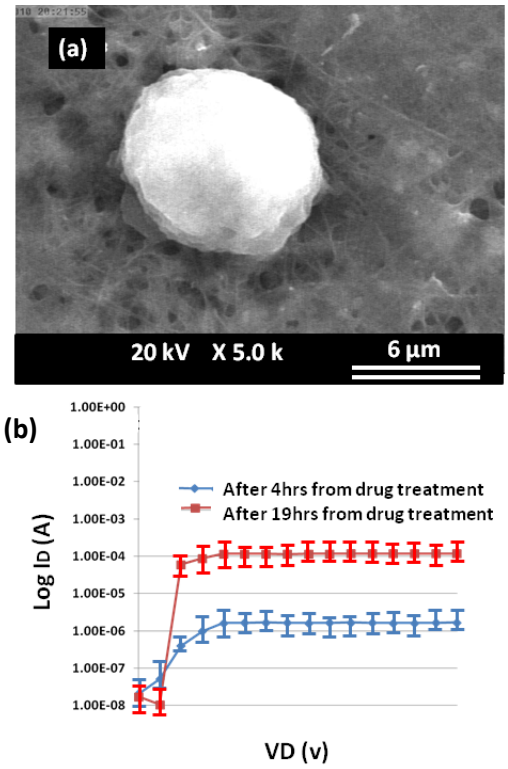
Electrically investigating the EDR assays on cancer cells by SiNW bioFET:

In EDR assays the drug effect on cancer cells viability will be investigated. Here this assay has been electrically studied by the negative charges degradation of treated cell membrane seeded on SiNW incorporated bioFET.

After culturing the SW48 cells on the nanowires grown on top of the gate surface, 20 µmolar of paclitaxel (Drug for epithelial cancer therapy with molecular formula: $C_{47}H_{51}NO_{14}$ produced in

Xi'an Hao-xuan Bio-tech Co., Ltd) was added to the seeded cells and they were incubated with the drugs for 4 and 19hrs. The comparison between figures 5-a and 5-b, which presented the SEM images of drug treated and original cancer cell cultured on nanowire covered gate respectively show that drug treated cells became more deformable and its size was smaller than original one.

Figure 5-c represents the output characteristic of the cell covered device after 4 and 19 hrs from drug treatment. The paclitaxel treated cancer cells have been turned to apoptosis phase so would be halted in maintaining their surface negative charges and due to the charges reduction; the transistor drain current has increased.



FigureS3. (a) SEM imaged from single SW48 cell immobilized on skein SINW covered on top of the gate surface after 19hrs from paclitaxel treatment. (c) The output current curves of cancer cells covered SiNW FETS after 4 and 19 hrs from paclitaxel treatment.

References

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