PLASMA TECHNOLOGY OF SURFACE processing OF THE pacemaker’s RUTHIUM ELECTRODES

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Electric Pacemaker (EP) is a device for electrostimulation of the myocardium, is widely used in the practice of treatment and rehabilitation after suffering heart attacks and other heart diseases [1]. One of the most important conditions for the operation of the EP is the stability of energy transfer in pulses from the endocardiac electrode (ECE) of the pacemaker to the heart and the optimal coordination of the parameters of the ECE. The electrical coupling of the electrode with the tissue of the myocardium is mainly capacitive, so it is necessary to minimize capacitance as much as possible. To stimulate the myocardium, an electrical impulse with a duration of 100–300 µs with an energy of 1–5 μJ is required; at the stimulation threshold of 1 V, the transient capacitance should be 2–10 µF. In the electrolyte of blood at the surface of the electrode when a potential is applied to it, an electric double layer (DEL) appears. The capacitive electrical resistance of the DEL significantly exceeds the ohmic resistance. A DEL is electrically equivalent to two series-connected capacitors, and its capacity is determined by the capacity of the internal dense part of the DEL and the capacity of the outer diffuse part of the DEL. To improve efficiency, it is necessary to increase the capacity of DEL. Two methods are used for this are (1) increasing the surface area of the electrode, creating a developed electrode surface, and (2) increasing the surface adsorption with special coatings. Modern pacemaker electrodes have a characteristic size of inhomogeneity of the developed surface of ~1 µm, which is less than the inner dense layer of DEL in less than 1 nm thick. Therefore, for pacemaker electrodes, the size of the surface structure elements should be reduced to 1 nm. Such structures of the "fuzz" type can be obtained by plasma processing of materials with plasma. A plasma device [2] has been constructed at NRU “MPEI” to produce a roughen nanostructured surface on metals, including the “fuzz” type.

Currently, the most promising are electrodes from the platinum group (platinum Pt and iridium Ir), the iridium coating has the lowest capacitance. Ruthenium Ru belongs to the platinum group of elements. For the first time, we propose using ruthenium Ru to cover ECE. Ru is a chemical analogue of iridium, but has several advantages for technology. Ruthenium is the only one of these elements naturally present in the human body. In addition, ruthenium is much cheaper than iridium. In the PLM facility [2] (NRU “MEI”), a nanostructured coating of ruthenium by sputtering the Ru target will be formed on the electrode at the plasma discharge. It is proposed to test several approaches, including the creation of a “fuzz” structure on the surface of titanium and subsequently sprayed on this structure ruthenium; or form a “fuzz” structure on the layer of deposited ruthenium. Such experiments open the way to develop a new technology for the manufacture of electrocardiac pacemakers with improved characteristics.

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References

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