Scientists to develop long-lasting battery with unorthodox methods

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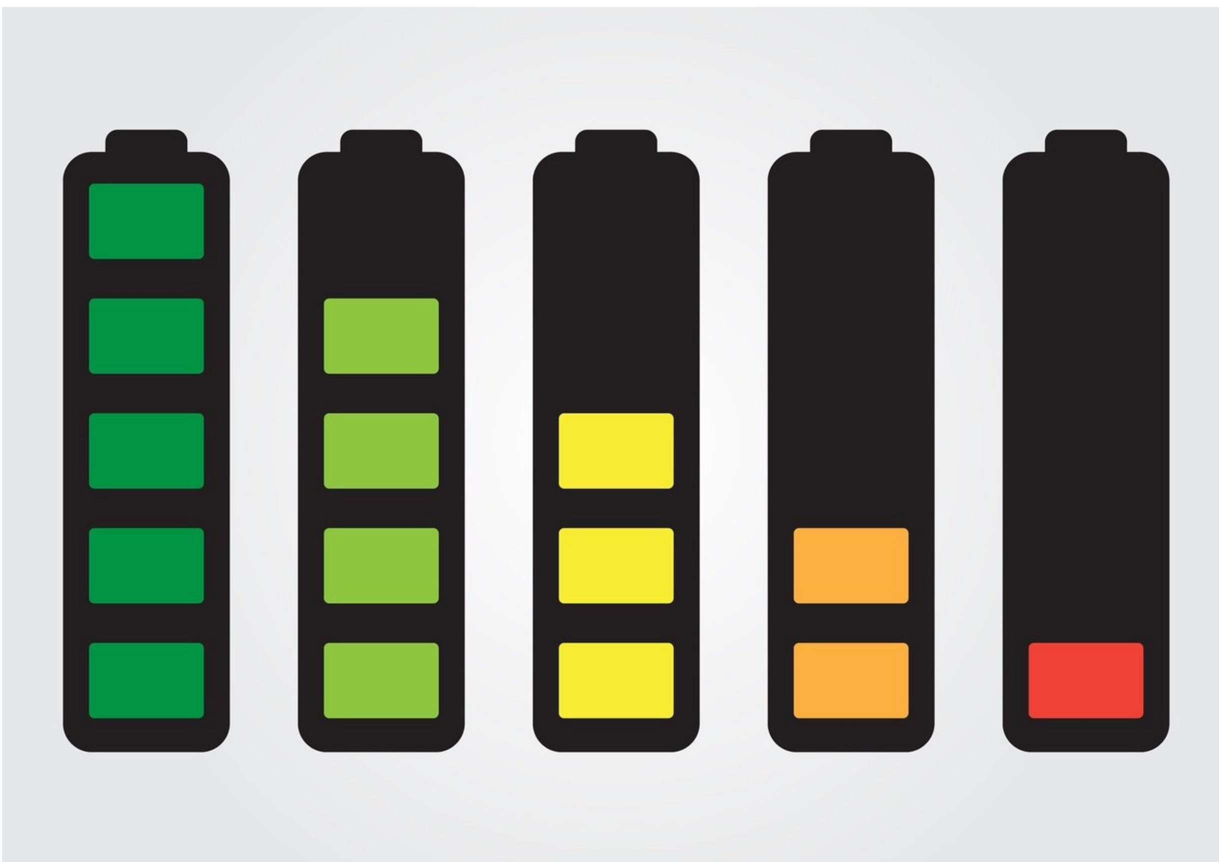

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Researchers from the National Research Nuclear University MEPhI (Russia) are developing radio isotope beta-voltaic batteries with nickel-63 nano-cluster radio isotope films. The concept is to develop safe nuclear batteries with a service life of 100 years for pacemakers, miniature glucose sensors, arterial blood pressure monitoring systems, and for controlling remote objects and micro-robots, and self-contained systems that can operate for a long time. Research results are published in the journal *Applied Physics Letters*.

Researchers are more interested than ever in projects to develop nanotech to miniaturize technological devices, primarily nano-electronic systems. The latest achievements in creating micro-electromechanical and nano-electromechanical systems that combine nano-electronics and mechanical elements can make it possible to develop microscopic physical, biological or chemical sensors. However, the lack of miniature batteries for powering micro-electromechanical and nano-electromechanical systems hampers the large-scale introduction of such devices.

Today, scientists are studying the possibility of creating miniature lithium-ion batteries, solar panels, fuel cells and various types of condensers. However, these batteries are still too large for developing truly microscopic and nano-sized systems.

Another approach to powering advanced micro-electromechanical and nano-electromechanical systems is the use of radio isotope batteries. radio isotope or nuclear or atomic batteries convert the energy of radioactive decay of meta-stable elements (atomic nuclei) into electricity. These elements have high energy density levels for their mass and volume. The duration of sustained energy emission varies, depending on the choice of nuclides. Silent radio isotope batteries can operate without an error or maintenance for a long time.

Unique Properties of Nickel-63

Thermo-electric conversion is seen as one of the most convenient methods for converting the energy of radioactive decay into electricity. But scientists are also studying beta-voltaic batteries and their practical applications. By installing a radio isotope that emits soft beta radiation in a miniature battery, it is possible to shield users and nearby objects from radiation. Therefore, such batteries would have wide-ranging applications.

MEPhI researchers studied the electro-physical properties of nano-cluster nickel film and selected optimal parameters of an experiment aiming to create a system for effectively converting the energy of the nickel-63 isotope's beta-decay into electricity. The nickel-63 isotope ranks among the most promising radionuclides in beta-voltaic processes. This soft beta-radiation emitter has a long half-life of 100.1 years. Consequently, this unique element is ideally suited for powering various systems that don't require high output.

Elastic, resilient, relatively inert and easy-to-machine nickel is an effective metal in terms of its properties. It does not have to be stored and transported inside containers. Researchers are attempting to boost the efficiency of current systems that convert the energy of the nickel-63 element's beta-decay into electricity and to find alternative physical systems. This approach is very promising.

MEPhI Researchers are Using New Approaches

Researchers have developed an unusual physical system to generate secondary electrons inside nano-structured nickel films and to considerably enhance the current signal caused by a cascade of numerous non-elastic collisions of beta-particles, said Pyotr Borisyuk, an assistant professor with MEPhI's Faculty of Physical-Technical Metrology Problems.

"It's relatively easy to make an experimental system that consists of an array of densely packed nickel nano-clusters with the gradient distribution of nano-particles on the surface of silicon oxide, a broad-band dielectric, depending on their size," he noted.

The researchers report that the formation of nickel-63 nano-cluster films with the gradient distribution of nano-particles combines two important processes. First, it becomes possible to develop coatings with a fixed potential difference determined by different nano-particle sizes in a preset direction. Second, it will convert the energy of the nickel-63 isotope's beta-decay into an electric current without using additional difficult to produce semiconductor systems.

The unique properties of emerging gradient nano-cluster nickel films. radio isotope power sources with thermoelectric conversion have almost unlimited applications. Tiny nuclear batteries could be used for micro-electromechanical and nano-electromechanical systems, pacemakers, miniature glucose sensors and arterial blood pressure monitoring systems, and for controlling remote objects and micro-robots, as well as self-contained systems that can operate for a long time in deep space, beneath the sea and in the extreme north.

More information: P. V. Borisyuk et al. Size-ordered 63Ni nanocluster film as a betavoltaic battery unit, *Applied Physics Letters* (2018). DOI: 10.1063/1.5010419

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