Nuclear Sources Encapsulated in Platinum Alloys

Batteries for Implantable Biomedical Devices

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Implanted biomedical electrical devices now serve to alleviate pain, dispense drugs, facilitate healing, sustain life and complement several body functions, and platinum metal electrodes are used for several of these purposes. This area of application requires a unique combination of electrical, environmental and reliability parameters, and is at least as demanding as the needs of space exploration, which prompted much work to improve electrical power sources.

Prior to 1960 there were few implantable devices, but the subsequent advancement of transistorised electronic components and the development of improved batteries facilitated the production of small, reliable, implantable instruments. More recently integrated circuit technology, lithium battery systems and nuclear power sources have been developed for this application, and some devices have given highly reliable service for up to ten years. However, new therapies require higher electrical power levels, and it would be advantageous if batteries were even smaller and lighter in weight.

With this continuing need for improvement, the publication of a technical monograph which summarises and assesses the technology of implantable batteries for biomedical applications, and also for use in other difficult environments, is highly welcome. Separate chapters consider electrically driven implantable prostheses, the evolution of implantable pacemaker batteries, lithium primary cells, methods of battery evaluation and performance modelling, lithium/halogen batteries, lithium solid cathode batteries, lithium-liquid oxidant batteries, mercury batteries and rechargeable electrochemical cells as implantable power sources. The final 68-page chapter by D. L. Purdy of Coratomic, Inc., Indiana, Pennsylvania, U.S.A. considers implantable nuclear batteries.

Radioactive decay can be harnessed by both the betavoltaic effect and by converting heat, which results from the decay of the nucleus of an atom, into electricity by the Seebeck effect. Plutonium-238 is a suitable isotope for this purpose, having a high energy density, a low level of penetrating radiation and a long half life. In addition it can be contained in a sealed capsule, which is essential to prevent release of the fuel into the biosphere and to retain helium produced during the disintegration.

Under all operational conditions and during any credible accident, the container must be totally reliable. One of the qualification tests employed involves heating it to temperatures in excess of 1300°C for 2 hours without the release of fuel. Others include corrosion testing in sea water, mechanical and vibration testing, and temperature cycling.

To meet the many requirements, Coratomic, who produce plutonium-238 powered cardiac pacemakers, make use of an inner high temperature pressure vessel made from tantalum-tungsten alloy, which is protected from oxidation by an outer sphere of rhodium-platinum, the two being separated by an oxide diffusion barrier. The same alloy is used in U.S. Atomic Energy Commission capsules, while platinum-iridium is used for the outer sheath of the fuel capsules in Laurens/Alcatel isotopic batteries, which power the Medtronic pacemaker.

Implantable nuclear batteries are regulated by national and international agencies; since they were first used in 1970 more than 3000 have been implanted, all as power sources for cardiac pacemakers, and their reliability has been exemplary. In the future, the high power output and long life of nuclear batteries may lead to greater application.