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Lithium batteries have played an important role in the development of useful implantable biomedical devices. The cardiac pacemaker is the most well known of these devices and high energy, long-life reliable lithium primary cells have effectively replaced all of the alkaline cells previously used in these electronic systems. The recent development of higher power devices such as drug pumps and cardiac defibrillators require the use of batteries with higher energy and power capabilites. High rate rechargeable batteries that can be configured as flat prismatic cells would be especially useful in some of these new applications. Lithium polymer electrolyte batteries may find a useful role in these new areas.

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THE USE OF LITHIUM BATTERIES IN BIOMEDICAL DEVICES

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Implantable biomedical devices are increasingly being applied to the treatment of diseases of the human body. For many years passive artificial devices such as hip joints, spherical plastic spacers and heart valves have been implanted into the human body to correct various forms of disability. About thirty years ago, battery powered devices started to play a useful role, as the first implantable cardiac pacemakers were used in clinical treatments[1]. Subsequently, many different designs of battery powered medical devices have been implanted in humans and literally millions of batteries have operated within the isolated, isothermal environment of the human body. Mercury/zinc oxide cells were initially used in cardiac pacemakers, but since 1972 the mercury batteries have been largely replaced by lithium primary batteries.

The lithium/iodine battery is the preferred power source for cardiac pacemakers, with an excellent reliability record. Although the high impedance lithium/iodine cell is ideally suited for the low power needs of implantable cardiac pacemakers, other biomedical devices require low impedance batteries for higher power drains. In devices such as implantable drug pumps, neurological stimulators and cardiac defibrillators, the circuit requires a low level background current as well as intermittent high power pulses. The lithium/iodine battery is incapable of meeting this type of power requirement.

As a result, several designs of increased power lithium batteries have been developed for these more demanding applications. Cathodes based on thionyl chloride, vanadium pentoxide and silver vanadium oxide have been coupled with lithium in implantable device batteries. The ability to deliver current pulses of up to several amperes has been designed into small sealed batteries. The highest current pulses, required by defibrillators, have been provided by the solid cathode cells. Intermediate current pulses (several milliamps) have been provided by thionyl chloride based lithium primary batteries, as well as some lithium organic electrolyte systems.

As the need for higher current pulses or higher average power output develops, primary batteries will be unable to provide continuous operation over several years. In this case, the secondary lithium batteries may find a useful role. They are superior to the aqueous rechargeable batteries because their self-discharge rates are lower, they are non-gassing and have higher energy densities. A totally implantable artificial heart needs a continuous source of about twelve watts of power continuously; a secondary battery would need to be charged on a daily basis for several years, (about1,000 cycles).

This need for the combination of high power density and high energy density with long cycle life will challenge available and developing power source technologies. New systems will have to be considered, including such batteries as the rechargeable lithium/inorganic liquid depolarizer systems and lithium polymer electrolyte batteries. The polymer electrolyte batteries are generally not promising for high power applications. However, some design studies indicate that a combination of ultra-thin electrodes with unique current collectors in a bipolar electrode structure may yield both high specific power and high energy density. Further, such batteries may also provide a unique shape factor advantage in that they could be configured as flat prismatic cells rather than the more conventional cylindrically shaped rechargeable batteries presently available commercially. In conclusion, lithium primary batteries are essential to the present state of the technology of implanted electrical biomedical devices. This need will continue and rechargeable batteries will find a significant role during the next phase of development[2].

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1. B. B. Owens, "Batteries for Implantable Biomedical Devices", Plenum Publishing Co., New York, 1986.

2. C. F. Holmes, "Implantable Power Sources: An Overview", Extended Abstract No. 26, 174th National Meeting of the Electrochemical Society, Chicago, 1988.