Packaging Design for Implantable Microstimulator

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Received 9 July 2003; Accepted 2 Sep 2003

Abstract

Implantable biomicrosystems for restoring neuromuscular functions have gained more attention for studying the characteristics of various types of neural interfaces. In our previous study, we have developed a microprocessor-based microstimulation system by using the surface mount device (SMD) components on printed circuit board (PCB) and stimulating electrodes, prepared for implantation into animal on neuromodulation studies. The aim of this study is to investigate the feasibility of packaging design of an implantable microstimulator. In current study, Micro Electro Mechanical System (MEMS) fabrication process for microassembly and interconnection on flexible polyimide substrates was employed to integrate microstimulator circuitry and nerve cuff electrodes as an implantable biomicrosystem for peripheral nerve applications to achieve a module package. The flexible mechanical structure design of microstimulator is more suitable for module design and implantation purposes. Dam-and-fill process was applied to seal the module, which was later encapsulated with medical grade silicone rubber for biocompatible package. The implantable microstimulator measured at 4 cm in diameter and 8 mm in height with cuff electrode interconnected to it. Finally, *in-vitro* experiment in the normal saline has confirmed that it is feasible to employ dam-and-fill encapsulation and medical-grade silicone rubber to package the biomicrosystem for a period of 30 days. The microstimulator is undergoing *in vivo* tests through the implantation of implantable microstimulator for stimulating rabbit's sciatic nerve.

Keywords: Hermetic packaging, Implantable microstimulator, BioMEMS, Biomicrosystem, Polyimide

Introduction

Research has shown that modulated stimulating current can activate the residual but intact sensory or motor nerves in order to generate sensation or functional movements. Therefore, using electrical stimulation to generate the artificial action potential, resembling real action potential is widely applied to innervate the dysfunctional organs. Among various applications, functional electrical stimulation (FES) has been employed to restore the deprived motor or sensory functions. For example, FES has been applied for movement control of paralyzed patients with spinal cord injury (SCI), in case that the peripheral nerves and muscles remain intact but lose the ability to activate them voluntarily. Among various FES applications, implantable microstimulator has been designed to be placed closely to the stimulation site and in an attempt to obtain more sophisticated movements.

In a boarder aspect, the implantable microstimulator can be considered as an actuator type of biomicrosystem. Currently, biomicrosystem including actuators, sensors or integration of them might utilize well-developed technology currently used in integrated circuits (IC) industry. As implantable biomicrosystems become more complicated, MEMS technology has been increasingly applied for developing implantable biomedical devices. These advanced microtechnologies generate new opportunities for the development of active implants that go beyond the design of current implantable devices. These microimplants demand a high level of device miniaturization without compromising on design flexibility and biocompatibility requirements. However, there are a number of difficulties, including miniaturization in size, low power, functional versatility, and stable and biocompatible packaging. More and more research groups are leaning to apply the micro-fabrication technology for the implantable or wearable/portable biomedical devices.

In general, a biomicrosystem consists of signal transduction and processing units, and the electromechanical packaging. The purpose of packaging is to provide mechanical support, electrical interconnection, and protection to the internal circuitry from all possible attacks from mechanical and environmental sources. In common with IC packaging,

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