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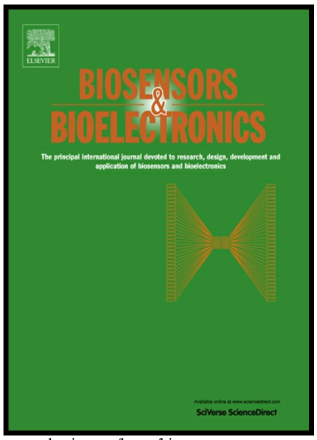

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Flexible deep brain neural probe for localized stimulation and detection with metal guide

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Abstract

In this paper, we present the design, fabrication, and performance evaluation of a polyimide-based flexible neural probe for the precise site stimulation and recording in the deep brain. The probe consists of five electrodes: one for stimulation, another for ground and the other three for recording electrodes. This probe is designed to be foldable, enabling easy insertion into the deep brain via temporary tungsten guide sticks. Because of its small cross-sectional area and the flexibility of the polyimide, the probe causes minimum damage to the neural tissue and does not show any evidence of serious immune reactions such as high density of macrophage or microglia. Around the simulation electrodes, an additional ground electrode prevents the stimulation of the undesired sites in the brain. To ensure we stimulate the target point specifically, for instance STh in this study, we confirm through both finite element analyses and *in vitro* tests. With the additional ground electrodes, we observe the leakage power decreased by about 80%. To check the performance of the probe, we demonstrate animal experiments using rats, and neural spike signals from STh in the 7-mm deep brain are successfully recorded after implantation.

Keywords: deep brain stimulation, implantable device, flexible neural probe, localized stimulation.

1. Introduction

Many neuroscience techniques have been used to study the structural and functional relationships in the brain, and brain potential mapping has played an important role in the healing of neurological diseases. In addition to rapid recent advancements in brain imaging techniques, such as magnetic resonance imaging (MRI)(Ahrens and Bulte 2013), positron emission tomography (PET)(Mathis et al. 2002), and computed tomography (CT)(Kalender 2000), electrical techniques continue to play an important role in brain mapping. However, short moments of electrical activity in the brain are difficult to record using imaging equipment because of the fast delivery velocity of neural signals.

Electroencephalography (EEG), which uses scalp electrodes(Romei et al. 2007), and intracranial EEG (IEEG)(Baek et al. 2014), which uses penetrating probes or surface electrodes, are alternative methods for acquiring fast signals from a local neural system in the brain. Such penetrating electrodes have also been applied to deep brain stimulation (DBS), cochlear implants, pacemakers, etc. to stimulate nerve tissues. In addition, seizure and epileptogenic zone localization can also be achieved with subdural and intracortical electrodes because of the short distance between the electrodes and neural systems. Recently, various neurophysiologists have developed multichannel cortical probes and/or electrodes with various materials and methods to acquire more meaningful outcomes and enhance stability and reliability.

In the development of such electrodes, rigid silicon(Calixto et al. 2013; Gabran et al. 2013; Michon et al. 2016; Nolta et al. 2015; Xu et al. 2002) and Iridium(Schmidt et al. 1996) have been widely adopted for the base