Micromachined Multichannel Cuff Electrodes for Interfacing Small Nerves

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Abstract-**Cuff electrodes are often used for interfacing nerves. Especially for small nerves, a new approach of flexible and light-weighted multichannel cuff electrodes with integrated cables has been developed using micromachining technologies. Here, the process technology is shortly introduced. The results of in vitro test were discussed. In vivo implantations showed excellent properties of the electrode nerve interface.**

Keywords: micromachining, stimulation, cuff electrode, polyimide, neural prosthesis

I. INTRODUCTION

Cuff electrodes are widely spread for stimulation of nerves and recording of afferent signals [1]. Most electrode devices were hand-crafted from platinum foils and silicone sheets. They guarantee a long life-time and only minor failure rates. Therefore, electrodes and insulation are normally "oversized". Here, we present micromachining technologies to fabricate flexible and light-weighted devices with integrated interconnects and discuss the results from in vitro and in vivo tests.

II. MATERIALS AND METHODS

We used micromachinig methods with equipment from semiconductor technology [2] to fabricate multichannel cuff electrodes (Fig. 1). Polyimide (Pyralin PI 2611/Dupont was chosen as substrate and insulation material. Electrodes, interconnection lines, and connection pads were deposited with sputter technology in platinum or iridium, respectively. A top layer of polyimide insulates the metallization.

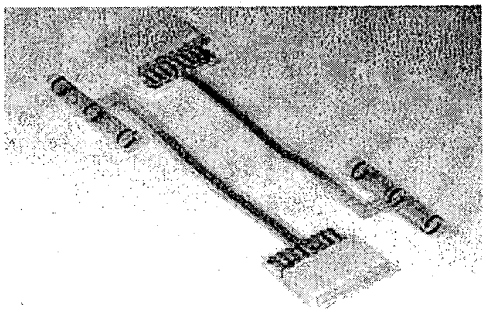

Fig. 1 Design of 12 polar cuff electrode with integrated interconnects.

Electrodes and connection pads were opened with reactive ion etching (RIE). RIE was also used to define the outer shape of the devices. In the last process step, the planar electrodes were separated from the wafer and rolled to the cuff-type shape. In a temper step, the mechanical stresses were mainly released. The material properties of the cuffs were tested in vitro in physiologic saline solution: stability of the cuff shape, charge delivery and impedance of the electrode sites in long-term scale. Acute stimulation on sacral roots in the dog animal model and chronic implantations in the rat sciatic nerve are under way.

III. RESULTS

We designed and realized cuff electrodes with diameters from 0.7 mm to 2.0 mm. The whole devices got a thickness of 10 µm and include 3 ring electrodes or 12 dot electrodes, respectively. They were highly flexible and robust to manual handling. They stayed stable in the rolled position during soaking tests in saline solution. The platinum thin-film metallization stayed stable during current pulsing at different amplitudes up to 2.0 mA (500 µs). In acute stimulation of the sacral anterior roots (S_2, diameter 1.5 mm) of the dog, we obtained good stimulation responses of the sphincter and urinary bladder. The data were comparable with clinically used electrodes.

IV. DISCUSSION

Cuff Electrodes were designed in two commonly known electrode arrangements. In principle, higher numbers of electrodes could easily be realized due to micromachining technologies. The thin-film electrodes and the polyimide cuffs were stable in saline solution and showed no cracking due to intrinsic mechanical stresses. Therefore, further investigations mainly should focus on degradation to explore the long-term behavior of the presented approach for chronic implantation.

V. CONCLUSIONS

We developed light-weighted, flexible cuff electrodes for small nerve diameters. They were flexible and robust at the same time. Electrodes showed stable in vitro properties and allowed in vivo stimulation.

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