Polymer-Encapsulated Single-Chip Implants for Bioelectronic Medicine

Nanbakhsh, Kambiz; Serdijn, Wouter A.; Giagka, Vasiliki

Publication date
2019

Document Version
Final published version

Citation (APA)
Nanbakhsh, K., Serdijn, W. A., & Giagka, V. (2019). *Polymer-Encapsulated Single-Chip Implants for Bioelectronic Medicine*. 1-1. Abstract from 7th Dutch Bio-Medical Engineering Conference, Egmond aan Zee, Netherlands. https://www.bme2019.nl/mobview/presentation/1027

POLYMER-ENCAPSULATED SINGLE-CHIP IMPLANTS FOR BIOELECTRONIC MEDICINE

Kambiz Nanbakhsh[1], Wouter Serdijn[1] and Vasiliki Giagka[1,2]

[1]Bioelectronics Section, Department of Microelectronics, Faculty of Electrical Engineering, Mathematics and Computer Science, Delft University of Technology

Mekelweg 4, 2628 CD, Delft, The Netherlands

[2]Technologies for Bioelectronics Group, Department of System Integration and Interconnection Technologies, Fraunhofer Institute for Reliability and Microintegration IZM

Gustav-Meyer-Allee 25, 13355, Berlin, Germany

e-mail: K.Nanbakhsh@tudelft.nl

ABSTRACT

The main goal of bioelectronic medicine is to, one day, replace conventional chemical drugs with miniaturized implants. This way, tiny electrical pulses will be locally delivered to a small group of neurons in order to influence and modify biological functions. Developing such implants, however, has brought many new challenges both in the technological and biological domains. One technical challenge, is packaging such tiny deceives in a way that protects the sensitive electronics inside from the harsh body environment [2], while, at the same time ensures certain flexibility that allows the implant to conform to the surrounding soft tissue.

Conventionally, medical implants have relied on a titanium (Ti) or ceramic box to protect the inside electronics. Driven by the increased functionality offered by CMOS technologies and the need for further miniaturization, in recent years tremendous efforts have been made in designing miniaturized implants by integrating the majority of components on a single chip [3]. Such a single-chip approach, however, would require novel packaging solutions since the box would consume greater volume compared to the chip and greatly limit the flexibility of the implant. Polymer encapsulation could be an alternative packaging solution which meets the physical constraints needed for bioelectronic medicine [1-2].

One main drawback of polymeric encapsulation, however, is the eventual penetration of water through the polymer. For this purpose, extensive efforts have been carried out on finding thin multi-layer coatings that could delay water and ion penetration and thereby, increase device lifetime [3]. Despite the increased protection offered by these layers, it has been shown that device lifetime can still be reduced when exposed to high electric fields. For example, the authors of [4] have found that continuous DC biasing of the device reduced the lifetime by a factor of 13 compared to a state where the devices were idle.

In this research, we intend to work towards a single-chip implant by investigating the effect of different electric fields on device lifetimes in soak conditions. For this aim, test structures have been fabricated in standard CMOS technologies and currently being tested in saline. More detailed and up-to-date results will be shared during the conference.

[1] V. Giagka and W. Serdijn, Realizing flexible bioelectronic medicines for accessing the peripheral nerves – technology considerations, Bioelectronic Medicine, vol. 4, no. 8, 2018, https://doi.org/10.1186/s42234-018-0010-y

[2] A. Vanhoestenberghe, N. Donaldson, Corrosion of silicon integrated circuits and lifetime predictions in implantable electronic devices, J Neural Eng, 2013, 10(3):1002–1015

[3] X. Xie, L. Reith L, P. Tathireddy, F. Solzbacher, Long-term in-vitro investigation of Parylene-C as encapsulation material for neural interfaces, Procedia Eng, 2011, 25:4.

[4] X. Xie, L. Rieth, R. Caldwell, S. Negi, R. Bhandari, R. Sharma, P. Tathireddy, F. Solzbacher, Effect of bias voltage and temperature on lifetime of wireless neural interfaces with Al2O3 and parylene bilayer encapsulation, Biomed Microdevices, 2015, 17, 1.