Ultra-Small Optogenetic Simulator Powered by CMOS-Integrated Optical Power Receiver

1. Introduction

Optogenetics is a technology with which light sensitive neural cells are realized by means of genetics. There is a large demand for ultra-small wireless power transfer device for optogenetic stimulation. We have proposed a CMOS-based optical energy harvesting with multiple small photovoltaic photovoltaic (PV) cells [1]. In this work, we present a design of the CMOS chip, device packaging and a functional demonstration of the ultra-small implantable optogenetic stimulator. Fig. 1 is a conceptual image of the proposed technology. We also present a next-generation chip with improved functionality.

2. Device design and fabrication

In order to realize the ultra-small implantable optogenetic stimulator, we integrated the PV cells onto the CMOS chip. In this work, we used a 0.35 µm standard CMOS process. In this CMOS process, pn junction with the largest PV efficiency is Nwell–Psub structure. However, as fabricated, the Psub structure is chip-wise shared and connected to the ground level. We introduced a post-CMOS Bosch process to separate the on-chip PV cells. Fig. 2 shows a block diagram of the ultra-small integrated optogenetic stimulator. The device consists of a CMOS optical power receiver circuit with integrated with PV cells, an external capacitor, and a light emitting diode (LED) [2]. An operation of the device starts with charging an external capacitor with the current generated by the integrated PV cells. When the voltage of the capacitor reaches $V_{TH}$, a voltage detector circuit turns on a CMOS switch and supplies power to the blue LED. After that, when voltage of the capacitor drops to $V_{TL}$, voltage detector turns off the CMOS switch and stops to supply power to the LED. Then, the capacitor voltage starts to increase toward next operation.

3. Conclusion

We proposed and realized a CMOS-based optical power receiver with integrated PV cells. The technology is suitable for ultra-small wireless electronics such as implantable devices. We realized an ultra-small implantable optogenetic stimulator that can be wirelessly operated by IR light. An improved CMOS chip with regulated LED current will be presented in the conference as well.

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References