CMOS 集積光電力伝送による超小型埋め込み光刺激デバイス

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

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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.

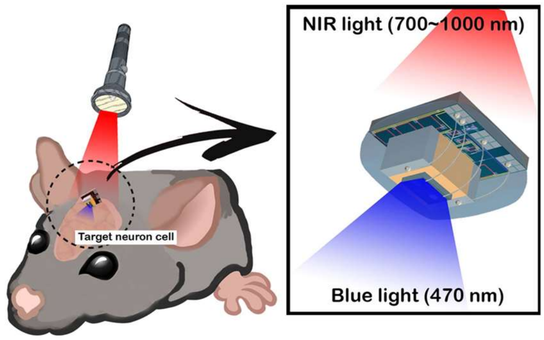


Fig. 1 Concept of the ultra-small implantable optogenetic stimulator.

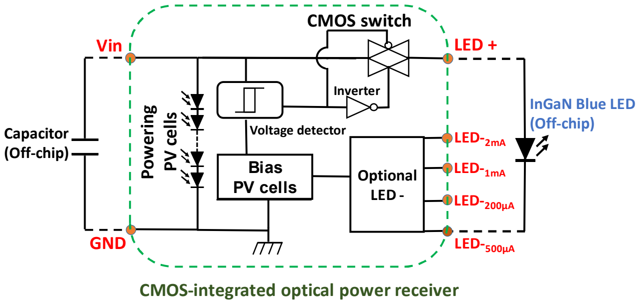


Fig. 2 Block diagram of the implantable optogenetic stimulator powered by the CMOS-controlled optical power transfer.

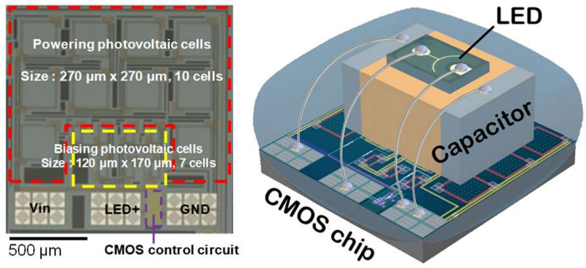
2. Device design and fabrication

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.

Table 1 Specification of the CMOS chip

Technology	0.35 μm 2-poly 4-metal std, CMOS process
Chip size	1.25 mm × 1.25 mm
Photodiodes	Nwell-Psub
Operating voltage	3.0~4.0 V
Number of pads	3
Terminals	Vin, GND, LED+



(a) (b)

Fig. 3 (a) Layout of the CMOS optical power receiver chip and (b) structure of the implantable optogenetic stimulator.

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.

Acknowledgements

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