Implantable bioimaging device based on CMOS image sensor technology

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Abstract Our studies on developing implantable devices based on CMOS image sensor technology are presented and discussed. The design of CMOS chips, packaging, experimental evaluations are described. The issues and difficulties, and future perspective are also discussed.

Key words Implantable device, On-chip imaging, Brain imaging, Optical stimulation, Retinal prosthesis

1. Introduction

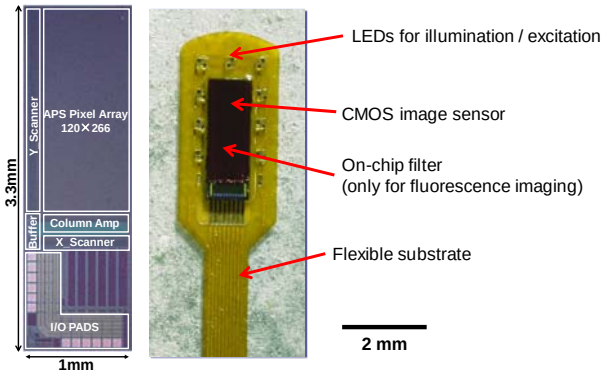
CMOS-based implantable bioelectronics have been attracting a lot of interest as an emerging research field. As the nature of Si devices, CMOS chip inherently compatible with electric neural interfacing and optical biosensing and imaging. Although light emission cannot be realized within pure-CMOS platform, various options such as hybrid integration are available.

We have been working on CMOS image sensor-based implantable microelectronics technologies, such as brain and neural imaging [1-3], retinal prosthesis [4-6], and so on [8]. The concept, sensor design, device implementation and other issues will be presented, and discussed.

2. Brain imaging and optical neural stimulation

There is a large demand of imaging brain activities including molecular expression or blood flow. We have developed a series of dedicated CMOS image sensors for implantable brain imaging device [1-3]. Fig. 1 shows (a) layout of the CMOS image sensor, and (b) assembled brain imaging device.

We also extended the functionality of the device as a neural stimulator. A GaInN LED array was integrated on a multi-functional CMOS image sensor with on-chip current injection capability [4]. As shown in Fig. 2, the device can be used for local light stimulator, which will be a powerful solution with optogenetics.



(a) (b)

Fig. 1 (a) layout of the CMOS image sensor, and (b) assembled brain imaging device [1-3].

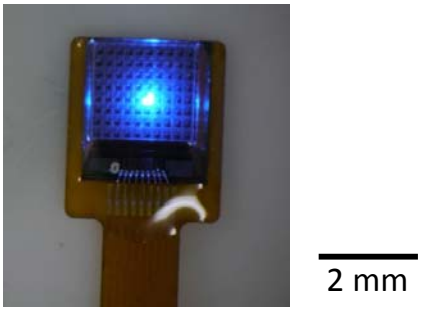
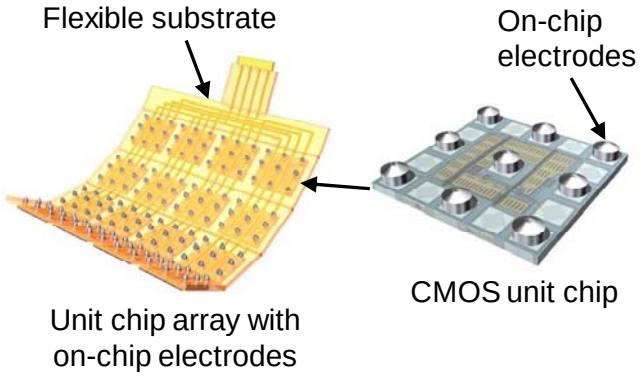


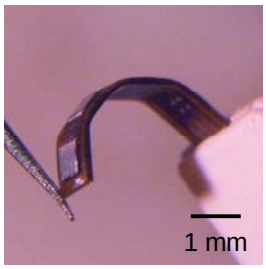
Fig. 2 CMOS-based optical neural stimulator for optogenetics [4].

3. Neural stimulator for retinal prosthesis

Retinal prosthesis is a technology that aims to provide a substitutional vision for blind patients. Clinical trials have been performed in U.S.A, Germany, Japan, and Australia. Although most of them are performed using simple electrode array, it is generally accepted that CMOS-based platform is necessary to achieve a high-density retinal stimulator with a large number of electrodes more than 100. We have proposed a device structure named "multi-chip architecture" with which we can realize a CMOS-based flexible retinal stimulator [5-7] (see Fig. 3).



(a)



(b)

Fig. 3 (a) Concept of "multi-chip architecture" and (b) device for animal experiment using a rabbit [5-7].

4. Summary

CMOS-based implantable imaging devices and related technologies are presented and discussed. As presented, the concept to use CMOS-based sensors and intelligent neural stimulators are promising as a solution technology for bioscientific and medical applications. Improved packaging, implementation of wireless technologies and accumulation of experimental demonstrative results are future works to apply these devices for wide-range applications in bioscience and medical fields.

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