



TRAINING4CRM

Electronic circuits for optical stimulation, bioimpedance, and electrochemical sensing

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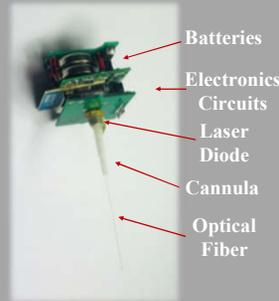
INTRODUCTION : Neurodegenerative disorders occur as a result of progressive loss of structure, function and/or death of neurons in the brain. The goal of the Training4CRM project is to address gaps in cell-based regenerative medicine for treatment of neurodegenerative disorders. We have designed a miniaturized wireless probe that generates blue light, which can activate genetically modified neurons to release neurotransmitters. This can be useful for restoring in a regulated manner the capability to produce the lacking neurotransmitter. We have also designed an electrochemical sensing circuit for a real-time monitoring of the neurotransmitter (dopamine in particular) release. It allows a better understanding of neuronal communication, and functional integration of implanted cells will be possible. We have used PSoC 63 Bluetooth Low Energy (BLE) Module to design the platform for optical stimulation and electrochemical measurements which provides a compact solution. Also, We are designing a CMOS integrated circuit to monitor growth, differentiation and integrity of cells through impedance spectroscopy.

RESULTS

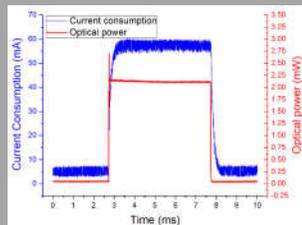
Optical Stimulation Headstage:

A System-on-Chip (SoC) with laser diode (LD) can be used for implementation of an optical stimulation circuit [1].

- ✓ It is based on Anaren's BLE SoC A20737.
- ✓ It is remotely controlled by a smartphone app.
- ✓ Adjustable optical power.
- ✓ Adjustable stimulation pattern.
- ✓ Total weight is 3.8 grams.
- ✓ Size : 14.6×15.1×18 mm³

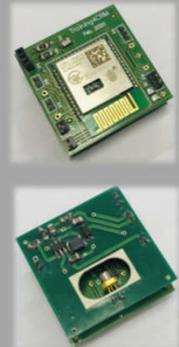


This Figure shows the total current consumption of the headstage and the optical power at fiber tip with 200µm diameter. During stimulation, the current consumption is around 60mA, where 55mA is given by the LD driver circuit and the LD.



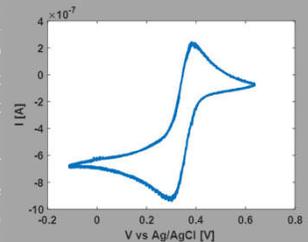
Optical Stimulation and Electrochemical Sensing Platform:

- ✓ The platform is based on PSoC 63 BLE module.
- ✓ The module has an integrated antenna, microcontroller unit, ADC, DAC, and opamps that we have used to design a compact and low power potentiostat for electro-chemical measurements using a 3-electrode technique.
- ✓ Total weight is 4.3 grams.
- ✓ Size : 26×26×14 mm³



CV measurement is performed in ferricyanide with 3-electrode setup (Au for WE, Ag/AgCl for RE, and Pt for CE). WE area is about 20000µm².

The WE current data successfully measured and transferred to the laptop through wired (UART) communication.



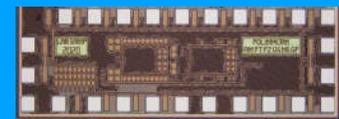
CONCLUSIONS:

- ✓ Compact platform to perform optical stimulation and electrochemical measurement have been proposed.
- ✓ Power efficiency is achieved by using laser diode as a light source, which generates light in a more concentrated way and provides better coupling efficiency with optical fiber.
- ✓ Can be used to perform amperometry or cyclic voltammetry
- ✓ Can be easily modified in order to be used with different range of input currents.
- ✓ Platform can be used by wireless or wired communication.

FUTURE WORKS:

Designing of a custom chip to monitor the neuron behaviour by measuring the impedance spectrum over a wide frequency range in addition to amperometry and cyclic voltammetry.

Chip micrograph of a 2nd order, single-bit continuous time delta sigma modulator



Dimension : 1.625×0.535 mm²

[1]: A. Mesri, M. Sampietro, A. B. Cunha, G. Ferrari and Ø. G. Martinsen, "A Laser Diode-Based Wireless Optogenetic Headstage," 2018 14th Conference on Ph.D. Research in Microelectronics and Electronics (PRIME), Prague, 2018, pp. 257-260.

ACKNOWLEDGMENT

This project has been funded by the European Union Horizon 2020 Programme (H2020-MSCA-ITN-2016) under the Marie Skłodowska-Curie Innovative Training Network and Grant Agreement No.722779.



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