LED and waveguide-based multichannel optical stimulation probes for optical Cochlea Implants

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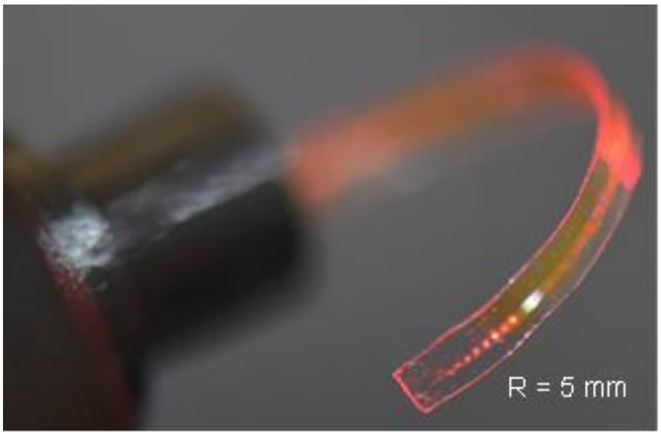
Amongst the many technologies which are enabled by the invention of the blue LED and laser diode is the development of implants for applications in optogenetics, a field within biomedicine. Nerve cells, but also other functionalities within living biological cells, can be stimulated by light, opening the possibility for both fundamental research and medical implants. Molecules in the cell membrane act as "light switches" which are activated after illumination within a certain wavelength range and are expressed in the cell by genetic methods. Most used is Channelrhodopsin ChR2 which is sensitive to blue light around 470 nm. However, the toolbox of opsins is continuously expanded, enabling different bio-medical functionality, but also requiring wavelengths from red to near ultraviolet for stimulation.

Bio-medical implants for optogenetics are based either on µLED arrays [1,2] or waveguides with laser diodes [3], both in stiff and flexible versions. I will discuss process technologies for both approaches. The stiff µLED implant was developed for stimulation in the cortex [1] while the flexible can also be used in the cortex, applying an appropriate implantation mechanism, but was originally developed for optical cochlea implants [2]. Both approaches allow stimulation of multiple sites in closely spaced areas of the neuronal tissue or inside the cochlea. In the case of the blue µLED array, the GaN-based light source is placed in close vicinity to the tissue, which has immediate implications for encapsulation and usage of bio-compatible materials in the implant. For the waveguide approach [3], the laser diode as light source can be placed in a remote, sealed encapsulation, with the need of an efficient and stable optical coupling to the waveguide probe.

I will address challenges and solutions regarding the integration of group-III-nitride based optoelectronic devices within bio-medical implants. Microsystem technology processes have been developed to integrate the semiconductor with flexible polymer [2,4] and on silicon-based MOEMS structures. In general, these processes are also of interest for MOEMS sensor systems, wearable devices, and flexible µLED displays.



Waveguide-based multi-channel optical cochlea implant.

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