Using microscopic light-emitting diodes to control brain cells and study neurological diseases

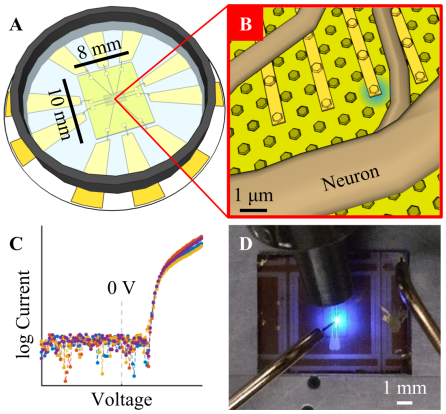
A popular science summary based on the master's thesis *μLEDs for optogenetics* by Lukas Wendt

IMAGINE if I said there was a way to control brain cells with light. You might first think of the scary mind control applications but would you also consider the potential to one day eradicate neurological diseases like epilepsy? Optogenetics is a fairly new technique in medical science and it is still a long way away from fulfilling either of these scenarios but that makes it no less interesting.

Today, optogenetics allow researchers to control nerve impulses by simply shining a light on cells that have been genetically modified with light sensitive properties of fluorescent algae. A common practice in optogenetics is to make cells sensitive to blue light and as luck would have it, blue light-emitting diodes, or LEDs for short, are relatively mature and straight forward to make with high quality. However, to study optogenetic effects subcellulary, for example how stimulation affects individual synapses, light sources would have to be microscopically tiny and this is where we come in.

By using tapered hexagonal platelet, gallium nitride μLEDs, less than 1 μm in diameter, situated on a small sapphire chip, we set out to make a prototype device for high resolution optogenetics (see figure **A**). LEDs were processed in Lund Nano Lab using microfabrication equipment for lithography, etching and thin film deposition before being characterized in a probe station rig. As we also wanted to be able to test actual nerve cell stimulation, we attempted to package the LEDs and passivate them for a biological environment with conducting fluids and sensitive nerve cells, which would have been grown directly onto the device, in close proximity too the LEDs (**B**).

Initial testing of the single platelet LEDs showed very promising electrical properties such as the clearly rectifying diode behavior (**C**) in addition to a rather extraordinary visible light output (**D**) for such small light source. Continued testing though, revealed short circuiting issues for larger LEDs with several platelets being coupled together in parallel. These issues could be explained by minute variations in original platelet height and be amended with future processing tweaks. Furthermore, actual optogenetic testing had to be abandoned as the complex packaging scheme, featuring thin film oxide passivated, wire bonds, would end up malfunctioning, suggesting a redesign is needed to remove unnecessary points of failure.



While we did not fully actualize the very ambitious goals we set out to achieve, our findings have undoubtedly aided in the understanding and fixing of issues with the platelet μLED technique so that development of it can progress. In a broader perspective, the technologies we explored are still highly interesting, combined and individually. Development of smaller LEDs and their use in more and more impressive optogenetic studies are published on a regular basis and inorganic μLED products are even starting to find their way onto the consumer electronics market in direct emitting, high resolution displays. To conclude, I am certain that even if this short text would have been the first time you heard about these topics, it will definitely not be the last.