Doctoral thesis/dissertation Digest Form

Title of Doctoral Thesis: Development of a miniaturized light source with an excitation filter for in-vivo imaging

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(Summary)

With the advancement of fluorescence selectivity technique as well as the rapid progress of CMOS technology, development of micro-dimensional fluorescence imager has been realized. This type of device comprises of a miniaturized custom-designed CMOS image sensor chip for optical imaging. It is integrated with a light source, typically either laser or LED-based. The LED is required to excite the brain specimen, which has been genetically modified for the purpose. Upon excitation by the LED, the brain cells emit green light, with spectral range similar to the green fluorescent proteins (GFPs)—typical fluorophore markers used in bioimaging applications.

Here, I fabricated a thinned InGaN based micro-LED loaded with an excitation filter. The LED used in this work has a thickness of 90 μm. This is considered invasive for an implantation application. Therefore, its thickness has been further reduced by using Laser lift-off (LLO) technique. Through LLO, more than 90% reduction of the micro-LED original thickness has been achieved.

The blue LED used here has an extended spectrum, up to the range of tens of nm - with its green-end band overlapping the GFP fluorescence spectrum meant to be detected by the image sensor. This green-end emission acts as background noise and affecting the quality of fluorescent image formed by the image sensor. It is therefore critical to use an optical filter to limit transmission of this unwanted component of the LED. A short-pass interference filter has been proposed here to specifically reduced the transmission of LED light of wavelength band above 475 nm. This interference filter performance is however greatly dependent on the angle of the light being emitted towards it. To resolve this problem, I introduced another optical device to function as light filtering component; a low- numerical aperture (NA) fiber optic plate (FOP). While the interference filter serves to limit transmission of the green light, the FOP purpose is to absorb and remove high angled light from reaching the interference filter.

Subsequent characterizations and experiments confirmed that the proposed device is fit to be use as an excitation source for fluorescent imaging.