

Internship for Master student:

Performances and robustness characterization of medium and high-brightness white LED arrays in overcurrent and few tens of nanosecond pulsed regime for automotive applications

Context and motivation:

The recent introduction of LED-based lighting for vehicles is set to improve driver safety and comfort at night, as well as during the day, and offer additional advantages in cabin lighting. The first LED rear lights and headlamps were fitted to production vehicles in 2003 and 2006, respectively. The benefits of LEDs, especially for headlamps, are now obvious, including the fact that their light color is very similar to daylight. LED headlamps are now being introduced by all major car manufacturers and are seen as the future of automotive lighting. Besides headlamps, LED-based lights can be also used for general and interior lighting. Their higher energy efficiency translates into lower fuel consumption and noxious emissions, helping manufacturers meet ever more stringent national or international standards. LED light sources have a much longer lifetime that can outlast that of the vehicle. They also offer an unprecedented level of design versatility that is essential for manufacturers, allowing them to differentiate their vehicles from the other competitors [1].

Focusing on 2020, solid-state lighting technologies for automotive applications will be based on systems involving white LED-based arrays of medium brightness (MB-LEDs). For specific functionalities requiring a more important available optical power, the use of high-brightness LEDs (HB-LEDs) will be relevant. However, the use of such HB-LEDs enforces to significantly modify the arrays design since the packaging of HB-LEDs is drastically different from that of MB-LEDs strongly pushing up the cost of the overall lighting system. For that, novel approaches for driving LED-based arrays are introduced especially in sub- μ s pulsed regime. Recently, some manufacturers (as CREE) explored the limits of some specific LED-based technologies under three types of overcurrent conditions [2]:

1. Single-pulse events similar to electrical overstress or EOS.
2. Repetitive pulsing (e.g. pulse-width modulation).
3. Ripple-current effects

It was reported in literature that it is possible to operate LEDs in continuous pulsed regime at high bias current levels (x 2-3 times of nominal operating current), but there are trade-offs that may adversely affect efficiency, chromaticity and long-term reliability. For instance, CREE recommends that customers perform their own lifetime testing when proving out a design that will deliver any of the three over-current conditions previously described. It is the customer responsibility to determine if the trade-offs will be acceptable. CREE cannot provide any guarantee regarding reliability or performance stability when using their devices outside the published specification limits.

Work description:

During this internship, IMS Laboratory and PSA will assess the performances and the operating robustness of MB-LEDs used in multiplexing "Smart Lighting" arrays and driven under overcurrent (largely above the nominal current) and few tens of nanosecond duration pulse. The objective of this study aims to validate if such a technique must be considered in comparison with the solution that consists in mixing MB-LEDs et HB-LEDs, all driven in CW regime but requiring to propose highly cost-consuming new packaging of these arrays.

Through accurate characterizations using dedicated setup and a detailed analysis of results, the student will particularly investigate on the assessment of performances and robustness of MB-LEDs arrays provided by OSRAM. In particular, the following tasks will be carried out:

- Technological analysis of the devices

- Setup implementation for electrical and optical characterizations (L-I-V, L(t), near field cartography, time-resolved spectral analysis)
- Metrology analysis
- Extraction of safe-operating area of the different devices in terms of peak current, pulse duration, duty cycle, operating frequency
- Initial characterizations and comparison with HB-LEDs driven in CW regime
- First investigations on long-term operating robustness of MB-LEDs arrays in overcurrent and few tens of ns pulse regime.

This internship will take part of a project between three partners - IMS Laboratory from University of Bordeaux, PSA Group (French leader in automotive) and OSRAM (global leader of innovative light solutions) – and will be supported by the Cluster of excellence LAPHIA. This Cluster is a unique Centre of excellence structure promoting Bordeaux as among the most visible centers in Lasers and Photonics at European and International levels, resulting in a strong attractivity for students, researchers and private companies. For more information see the following website <http://laphia.labex.u-bordeaux.fr/en/>.

The student will also take benefit from the large experience of IMS in the field, particularly in electrical and optical characterizations (OPERAS platform) as well as reliability assessment of photonic devices such as LEDs and Laser diodes. Some works have been reported in recent peer-reviewed papers and talks given in international conferences (for example see [3-6]).

Location:

IMS Laboratory, University of Bordeaux, UMR CNRS 5218, 351, Cours de la Libération 33405 Talence Cedex-France

Research group : EDMiNA Team (see <https://www.ims-bordeaux.fr/en/recherche/research/100-waves/edmina/90-edmina>)

Internship duration: 6 months - Starting date : July 1, 2018

Skills of the applicant:

Good knowledge in Photonics, Electrical/Optical Engineering, Materials Science, Physics or related fields is mandatory. Candidates must be interested in laboratory experience, characterization of miniaturized devices and sub-systems using electrical and optical instrumentation. Candidates must have excellent organizational, strong reporting and presentation skills as well as the ability to work both individually and as part of a team.

Supervisors:

Yannick DESHAYES: Associate Professor, EDMiNA Team - IMS Laboratory – University of Bordeaux (yannick.deshayes@u-bordeaux.fr)

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References:

- [1]- M. FACHOT, "LEDs light the road ahead in automotive applications", LEDs Magazine, pp. 45-47, 2013.
- [2]- CREE, "Pulsed Over-Current Driving of Cree ® XLamp® LEDs: Information and Cautions, Application Note, N° CLD-AP60 rev 1D, 2016.
- [3]- "Stark effects model used to highlight selective activation of failure mechanisms in MQW InGaN/GaN light emitting diodes", Y. DESHAYES, L. BECHOU, Y. OUSTEN, IEEE TDMR, 10(1), pp. 164-170, 2010.
- [4]- "Effects of silicon coating degradation on GaN MQW LEDs performances using physical and chemical analyses", R. BAILLOT, Y. DESHAYES, L. BECHOU, T. BUFFETEAU, I. PIANET, C. ARMAND, F. VOILLOT, S. SORIEUL, Y. OUSTEN, MICROEL. RELIAB., 50, pp. 1568–1573, 2010.
- [5]- "Analysis of optical responses of 1060nm seed Laser Diodes under overcurrent and short-pulse conditions for reliability investigations", G. LE GALES, S. JOLY, G. PEDROZA, A. MORISSET, F. LARUELLE, L. BECHOU, SPIE EUROPHOTONICS CONF., Brussels, Belgique, Paper 9892-70, 2016
- [6]- "Seed Laser Diodes In Pulsed Operation: Limitations and Reliability Investigations", G. LE GALES, S. JOLY, G. MARCELLO, G. PEDROZA, A. MORISSET, F. LARUELLE, L. BECHOU, Proc. SPIE 10098, San Francisco, California, USA, 2017.