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Design and Fabrication of High Temperature Optocoupler for High Density Power Module

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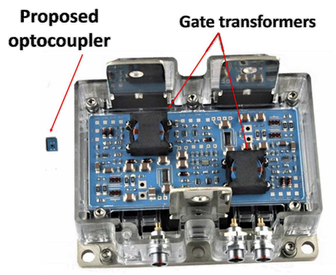
Motivation

- High-density power electronic modules require galvanic isolation between low-voltage digital (control) elements and high-voltage (power) components in the electronic module.
- Isolation transformers are generally preferred for high-temperature operation (>200°C).
- High form factor isolation transformers limits scaling-down of power electronic modules in size and weight sensitive applications, such as electric vehicles, motor drives, and space exploration vehicles.
- A further scale down is possible by creating optical links using optocouplers with low form-factors.

Objective

- A systematic study of the hi
  optoelectronic devices, i.e., er
  their packaging techniques.
- Develop a reliable high-tempe
  gate transformers.
- Ten –year projected lifetime a
  temperature**.**
- **~500 times** volume **reduction** f

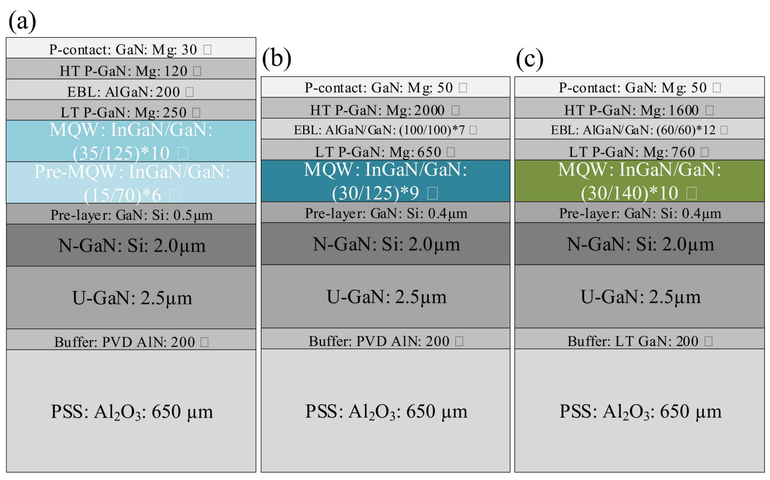


SiC vehicular inverter drive power module

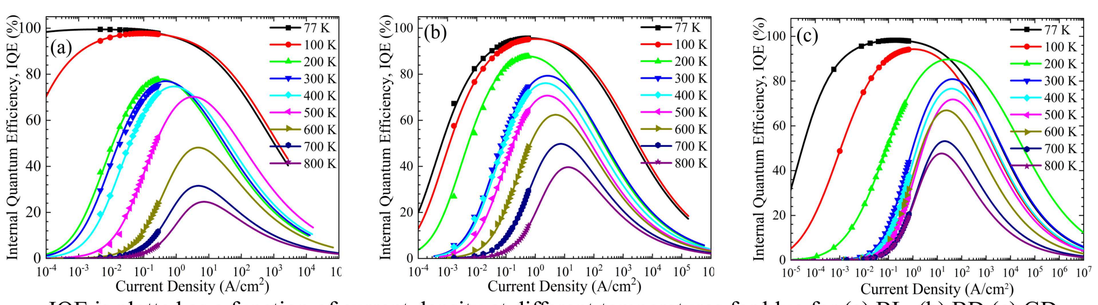
Results

1. Material & Device Level Characterizations

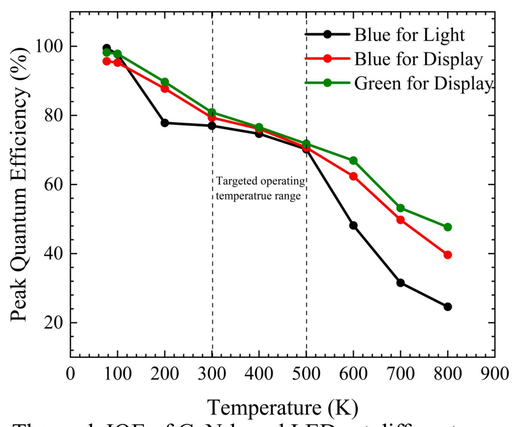
- Three different LED structures (peak λ = 460nm, 474nm & 530nm), suitable for high temperature applications, are characterized for a wide range of temperatures.



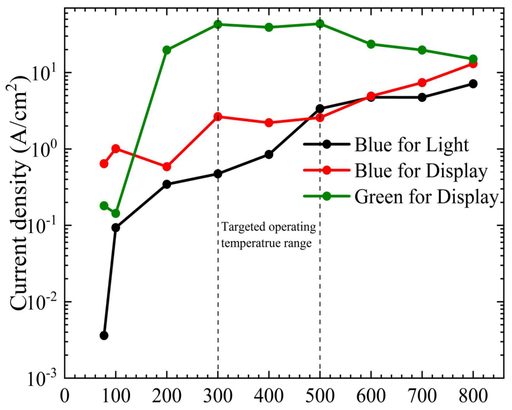
Schematic of the epitaxial structure of (a) blue for light (b) blue for display and (c) green for display LEDs.



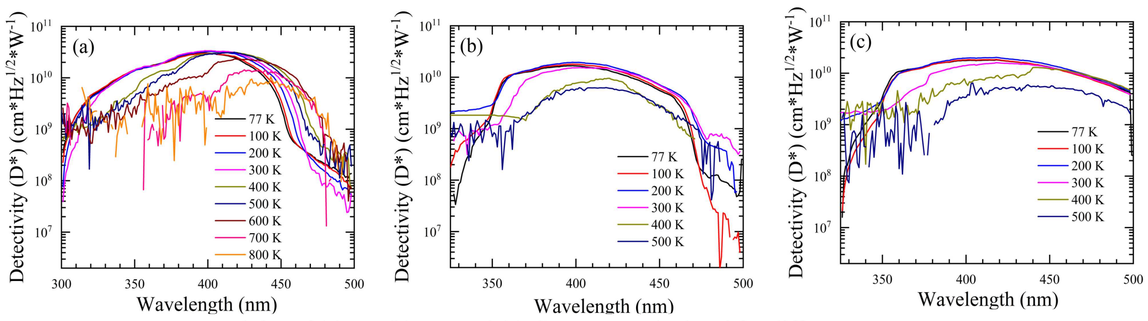
IQE is plotted as a function of current density at different temperatures for blue for (a) BL, (b) BD (c) GD.



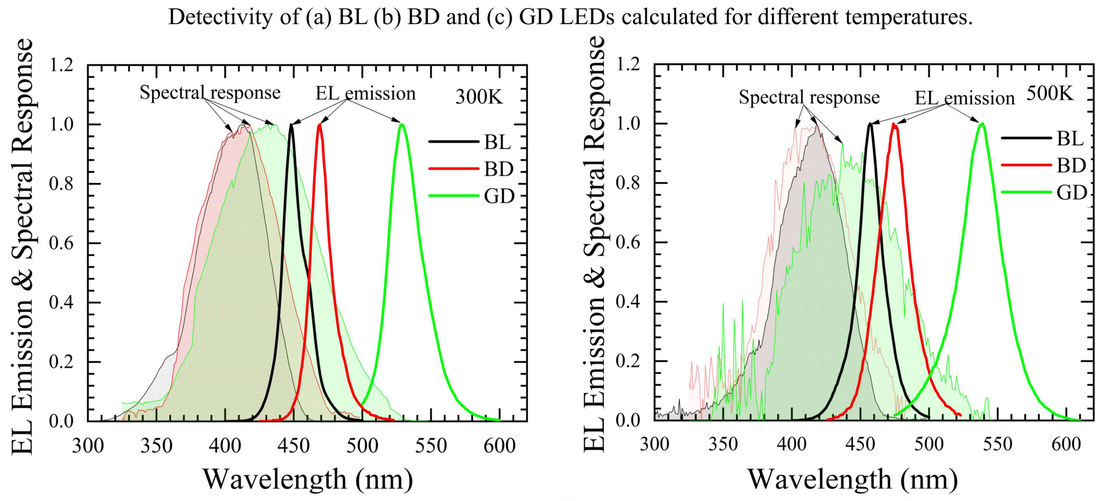
The peak IQE of GaN-based LEDs at different temperatures are extracted and plotted.



The injection current density corresponding to the peak IQE of GaN-based LEDs at different temperatures are extracted and plotted.

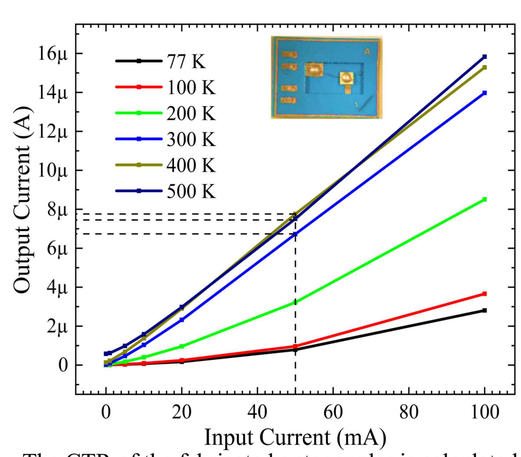


Detectivity of (a) BL (b) BD and (c) GD LEDs calculated for different temperatures.

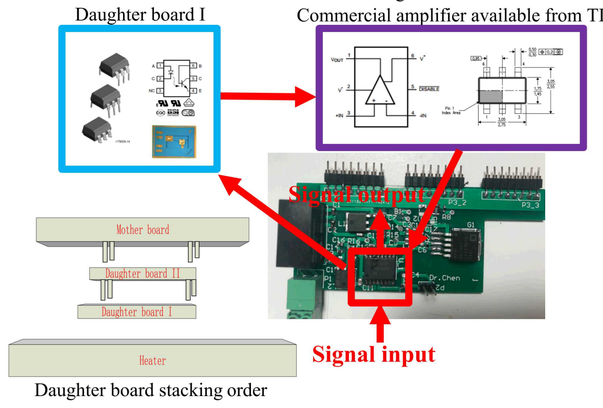


EL emission and spectral response of different LEDs at room temperature and elevated temperature

2. Packaging & Board Level Characterizations



The CTR of the fabricated optocoupler is calculated at elevated temperatures



Daughter board stacking order

Board level test plan for fabricated optocouplers

Future Works

- High temperature CTR analysis of different LTCC packages.
- Testing gate driver circuit at high temperature using LTCC based optocouplers.
- Integration and testing of the LTCC based optocoupler with the power module.

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Publications

- A. Sabbar*, S. Madhusoodhanan*, S. Al-Kabi, B. Dong, J. Wang, S. Atcitty, R. Kaplar, D. Ding, A. Mantooth, S. Yu, and Z. Chen, “Systematic Investigation of Spontaneous Emission Quantum Efficiency Drop up to 800K for Future Power Electronics Applications”. IEEE Journal of Emerging and Selected Topics in Power Electronics, Nov. 2018. DOI:10.1109/JESTPE.2018.2882775.
- S. Madhusoodhanan, A. Sabbar, S. Al-Kabi, S. Atcitty, R. Kaplar, B. Dong, J. Wang, S. Yu, Z. Chen ;”High-Temperature Optical Characterization of Wide Band Gap Light Emitting Diodes and Photodiodes for Future Power Module Application", Advances in Science, Technology and Engineering Systems Journal, vol. 4, no. 2, pp. 17-22 (2019).
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- A. Sabbar*, S. Madhusoodhanan*, S. Al-Kabi, B. Dong, J. Wang, S. Atcitty, R. Kaplar, A. Mantooth, S. Yu, and Z. Chen, “High Temperature Spontaneous Emission Quantum Efficiency Analysis from Blue and Green LED Materials," IEEE Photonics Conference (IPC), San Antonio, TX, 2019

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