

## **New Approach to Cathodoluminescence Studies in Application to InGaN/GaN Laser Diode Degradation**

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Spatially and spectrally resolved cathodoluminescence (CL) studies performed in scanning (SEM) and scanning transmission (STEM) electron microscopes are widely employed for determining the local spectrum of luminescence, mapping of the optical activity in the semiconductor materials and structures, revealing defects and measurement of recombination parameters.

We report on the dependence of CL intensity and its spatial distribution on currents and resistances in investigated semiconductor structures, especially on the layer sheet-resistance ( $R_S$ ), a basic characteristic of thin films. This effect has not been previously accounted for in CL studies by other authors.

The region where this effect impacts CL measurements may be misinterpreted as a region of higher defectivity, while it can be a nondefected region with its size dependent on the sheet-resistance of layers. Such inadvertent impact of resistances may occur even for structures without metallization or external connections, especially at room-temperature, when junction currents are larger than at low temperatures. It also changes the measured CL spectrum in spectrally resolved CL studies, because emitted signals are most sensitive to the described dependence at specific wavelengths, usually that corresponding to the quantum well, e.g. for violet luminescence in the measured devices. For avoiding measurement ambiguities this effect should be either avoided or considered in experiments relying on CL measurements.

To illustrate the new approach, cathodoluminescence studies in SEM, considering also the current and resistance dependence, were applied for analyzing degradation due to aging processes in laser diodes (LDs). They were InGaN multiquantum well (MQW) oxide-isolated, ridge waveguide LDs, grown on low dislocation density GaN bulk crystals, with epitaxial layers deposited by metalorganic chemical vapor deposition (MOCVD).

The CL dependence on the electron beam placement, either at the stripe area or on both sides of the mesa in the regions of lateral confinements, illustrates the laser aging effects in these structures, because the mesa is the site of an increased junction-current flow during the aging. It is shown that an analysis of CL characteristics without considering the current and resistance impact on measurement values, would bring erroneous and misleading conclusions regarding LDs degradation.