LOCAL V-DEFECT ENVIRONMENTS UNDER EXCITATION-DEPENDENT TRANSIENT CATHODOLUMINESCENCE

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V-defects, observed in group-III nitride compounds, originate from threading dislocations present in the epitaxial layers and may serve as an effective tool to mitigate the impact of dislocations on device performance. While the influence of V-defects on carrier dynamics is being actively studied, a complete understanding is still lacking. This study is set to investigate V-defects using time-resolved cathodoluminescence (TRCL), linking essential parameters - carrier lifetime, spectral characteristics, and defect architecture.

As defect size is considered to be directly related to defect properties, we study hundreds of V-defects from eight InGaN samples with different structure and material quality, grouped according to defect size. Each defect was individually measured, obtaining cathodoluminescence maps and streak images by beam-pointing across its geometry. Subsequently, profiles were constructed for each defect, showing cathodoluminescence intensity and carrier lifetime variations from the defect center to its periphery along both directions. Measurements were also performed using varying probe currents (1.5 - 33 pA) for selected defect groups in samples with contrasting internal quantum efficiency (IQE).

Each defect was evaluated using a measure of profile depth for intensity and lifetime, defined as I_p/I_c and τ_p/τ_c. Results for defects of different sizes (from 30 nm to 5 μm) reveal a positive correlation between defect size and profile depth for both intensity and lifetime profiles. Higher number of carriers reaching dislocations and participating in nonradiative recombination can be expected in defects with larger diameters due to weaker carrier localization in the quantum wells formed on the extended sidewalls. Thicker sidewall quantum wells formed early in the growth process and a smoother potential landscape can affect localization, increasing carrier interaction with defect-related nonradiative centers.

Defect profiles obtained under varying excitation conditions provide additional insight into carrier recombination processes. In this case, a minor negative correlation between probe current and profile depths τ_p/τ_c and I_p/I_c is observed for both high-IQE and low-IQE samples.

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