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Cathodoluminescence for bulk and nanostructured Gallium Nitride-based LED materials

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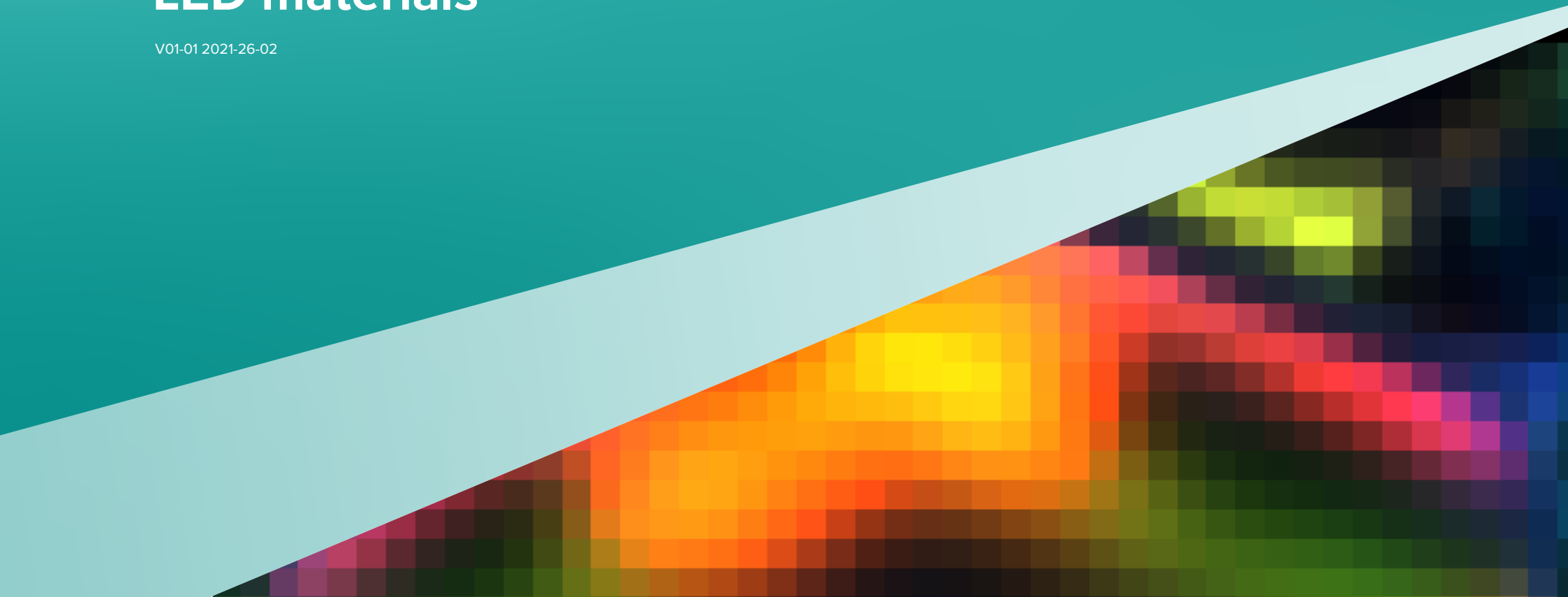

Cathodoluminescence for bulk and nanostructured Gallium Nitride-based LED materials

Gallium Nitride (GaN) is a versatile wide-bandgap semiconductor material and member of the family of III/V semiconductors. It is a hard, robust material with exceptional optical and electrical properties. As such, it is employed in a wide variety of applications including LEDs for lighting and displays, laser diodes, and high-performance electronics (high voltage, temperature, and/or frequency).

For LED applications, GaN is normally grown in a heterostructure form with a number of $In_xGa_{1-x}N$ quantum wells (QWs) which shift the light emission from the native band-gap energy of 3.4 eV (365 nm) in the ultraviolet to the visible part of the spectrum.

Figure 1(a) shows such a device in cross section. It is composed of a p-doped GaN top layer, an AlGaN barrier layer, 10 InGaN QWs, and an n-doped GaN layer on a sapphire substrate. The device was grown by metalorganic chemical vapor deposition (MOCVD) which is a standard method for growing high-quality III/V materials [1,2].

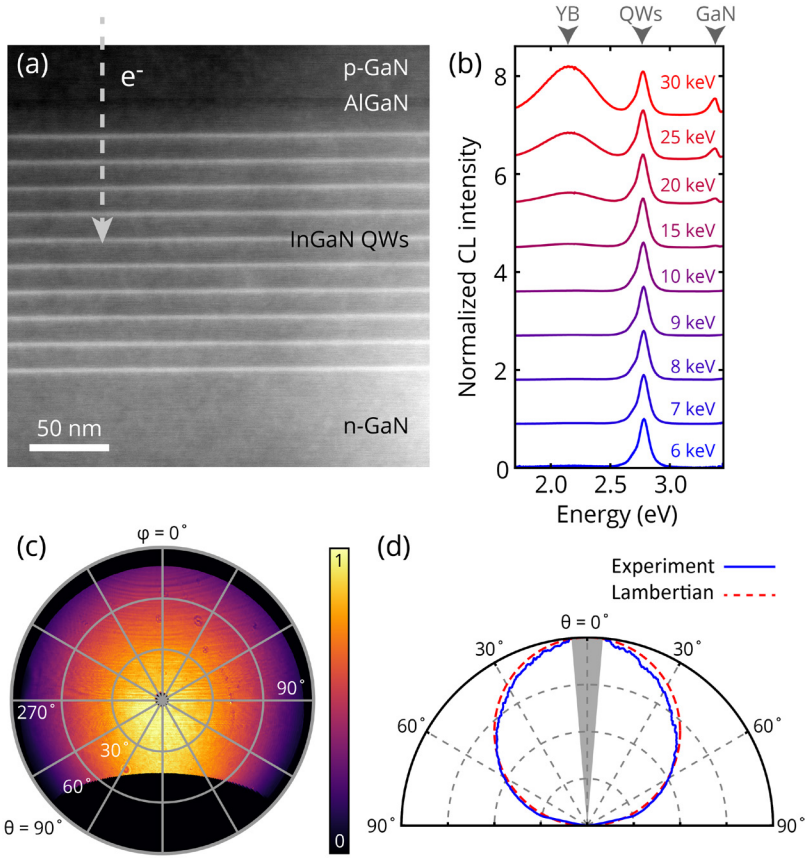

Figure 1: (a) HAADF STEM image taken on a cross-sectional lamella of a (In)GaN heterostructure prepared with focused ion beam milling. The different layers are indicated in the image. For reference the incident direction of the electron beam is also shown (b) CL spectra collected at different acceleration voltages, showing the characteristic YB, QW and GaN band gap emission (t = 250 – 500 ms , HV = 6 – 30 kV, I = 10 pA). (c) Angular CL profile (t = 10 s , HV = 10 kV, I = 20 pA). At this voltage the emission is dominated by the QWs. (d) Cross section through (c) showing the Lambertian nature of the QW emission. Sample courtesy of Michael Latzel, Martin Heilmann, and Silke Christiansen (Max Planck Institute for the Science of Light, Erlangen). Data taken from Ref. [1]