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Electroluminescence vs. Photoluminescence

This application note presents a brief comparison in characterization of light-emitting material such as GaN using electroluminescence and photoluminescence.

In photoluminescence (PL), excess carriers (electrons and holes) are photo-excited by exposure to a sufficiently intense light source, and the luminescence emitted from the radiative recombination of these photo-excited carriers. PL mapping combines conventional PL with a scanning stage. Both the intensity and the peak wavelength uniformity across the whole wafer can thus be acquired and used for evaluation. Electroluminescence (EL) is similar to photoluminescence, except that in electroluminescence the excess carriers are produced by current injection and it is usually measured on finished device.

The photoluminescence is mainly determined by the optical properties of the material, while the electroluminescence is determined by a number of factors such as the optical properties and physical structures of the optically active layers, the electrical properties of two conductive regions which are used for cathode and anode contacts, and the properties of the electrical contacts through which the electrical current injected. It is well known that photoluminescence is not equivalent to electroluminescence. High photo-luminescence efficiency is necessary but not sufficient for good light-emitting materials or wafers. A wafer with high photoluminescence efficiency may or may not exhibit high electroluminescence efficiency and hence good light emitting diodes (LEDs). The different emission mechanism between PL and EL could also result in huge emission wavelength/intensity change. It has been reported that, at least in green LED, top contact layer could change the MQW PL emissions dramatically, and EL spectra from the fabricated devices were very different from the MQW PL measurements. The reported phenomenon indicates that using the conventional PL measurements to optimize LEDs could bring misleading results.

Electroluminescence is usually performed on the finished devices (such as LEDs) since it needs a device structure to inject current. Conventional electroluminescence evaluation could not provide fast response for material development since the fabrication of devices is usually time-consuming and costly. MaxMile Technologies' EL mapping technology overcomes this limitation by temporarily forming a well defined light emitting diode (LED) inside the material. It characterizes the electroluminescence behavior of light emitting material as the finished device functions through electroluminescence. The technology is nondestructive in nature, which allows light emitting material/wafers to be inspected or measured without damage. It has the capability for both wafer-level and micrometric-scale evaluation. Since the characterization does not interfere with sample's final use, this technology enables fast response for material development and provides an excellent balance between quality control and cost-effectiveness. The system also has the capability to evaluate the photoluminescence and electrical properties of the light-emitting materials, which provides extra dimensions of information to thoroughly evaluate the material.

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