Determination of Internal Quantum Efficiency in Semiconductors Suitable for Luminescence Refrigeration

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Semiconductor based luminescent refrigerators are attractive for applications in the area of the integration of coolers with other semiconductor devices, such as, infrared sensors and low-noise electronic circuits. However, since near unity internal quantum efficiency is critical for the achievement of luminescence refrigeration, it is necessary to have routine, straightforward, and accurate measurement techniques for internal quantum efficiency. Although substantial efforts have been devoted to such measurements, there are few straightforward methods that offer reliable data. In this paper, a simple experimental approach is used to determine the internal quantum efficiency of a set of specially designed GaAs-based samples. Excitation pumping power dependent photoluminescence measurements are performed at 300, 230, 100 and 50 K. The resulting integrated photoluminescence intensities are fit to a model by assuming
1) the fraction of pumping laser power absorbed to generate the carriers in the active region is independent of the pumping power;
2) the luminescence extraction and loss due to the collection system and spectrometer are independent of the pumping power;
3) the Shockley-Read-Hall, radiative, and Auger recombination coefficients are independent of the pumping power. When the pump laser power density is around 40 W/cm2, the internal quantum efficiency is determined to be 0.987 at 50 K and 0.806 at 300 K for bulk GaAs. Further details of this approach and additional experimental results will be presented.

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