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A comparative analysis of the effect of temperature on band-gap energy of gallium nitride and its stability beyond room temperature using Bose-Einstein model and Varshni'S model (Article)

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Abstract

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High temperature stability of the band-gap energy of the active layer material of a semiconductor device is one of the major challenges in the field of semiconductor optoelectronic device design. It is essential to ensure the stability in different band-gap energy-dependent characteristics of the semiconductor material used to fabricate these devices either directly or indirectly. Different models have been widely used to analyze the band-gap energy-dependent characteristics at different temperatures. The most commonly used methods to analyze the temperature dependence of band-gap energy of semiconductor materials are: the Passler model, the Bose-Einstein model, and Varshni's model. This paper is going to report the limitation of the Bose-Einstein model through a comparative analysis between the Bose-Einstein model and Varshni's model. The numerical analysis is carried out considering GaN, as it is one of the most widely used semiconductor materials all over the world. From the numerical results it is ascertained that below the temperature of 95 K both the models show almost same characteristics. However, beyond 95 K Varshni's model shows weaker temperature dependence than that of the Bose-Einstein model. Varshni's model shows that the band-gap energy of GaN at 300 K is found to be 3.43 eV, which establishes a good agreement with the theoretically calculated band-gap energy of GaN for operation at room temperature.

Author keywords

Bandgap energy Bose-Einstein model GaN Temperature Varshni's model

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