Carrier Concentration-Dependent Optical Properties of Narrow Gap Semiconductors

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This work provides a comprehensive assessment of the optical properties of narrow bandgap semiconductors based on the k·p method [1] across a wide range of carrier concentrations and wavelengths. Based on a commonly used two-band model [2] and a less explored three-band model that include the spin-orbit split-off band, the refractive index and absorption coefficient due to free-carrier absorption are evaluated and compared with experimental data to assess their suitability for different scenarios. It is found that the values of electron energy based on the two models can substantially differ as the carrier concentration is increased. Fig. 1 shows the energy calculations for InAs, with the resulting effective masses shown in Fig. 2. The refractive index and absorption coefficient calculated from the two models will have some differences that depend on the carrier concentration. The results provide a guideline for selecting the appropriate model in different wavelength and carrier concentration ranges for various applications. The attained results may help with the optimization of interband cascade laser performance and other applications, and lead to improved device performance and more accurate measurements.

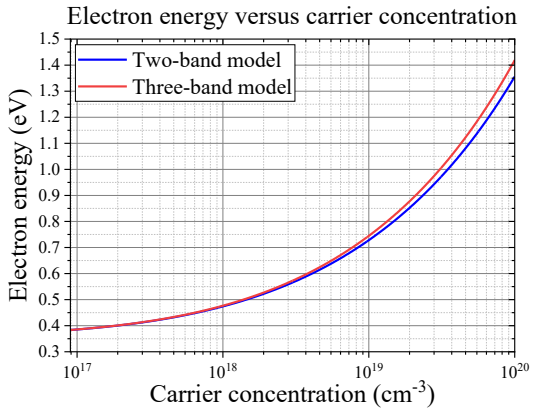

Fig. 1 Electron energy versus carrier concentration based on the two models for InAs.

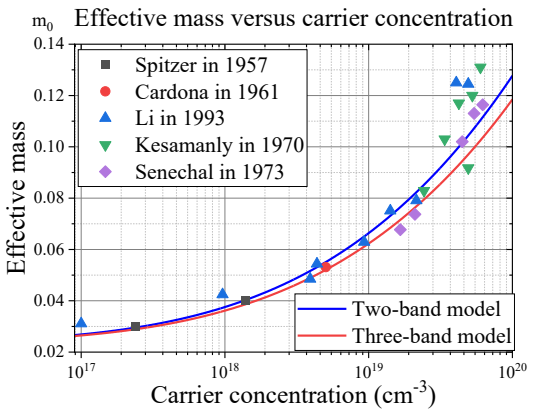

Fig. 2. Calculated effective mass versus carrier concentration based on the two models compared with experiment data from literature.

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[1] E. O. Kane, "Physics of III-V compounds," Chapter 3 in Semiconductors and Semimetals, edited by R. K. Willardson and A. C. Beer (Academic, New York, 1966), Vol. 1.

[2] Y. B. Li *et al.*, "Infrared reflection and transmission of undoped and Si-doped InAs grown on GaAs by molecular beam epitaxy," *Semiconductor Science and Technology,* vol. 8, no. 1, pp. 101-111, 1993.

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