Determination of the hole concentration in p-type GaN by Raman spectroscopy

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Nowadays GaN is one of the most important semiconductors in the range of applications in optoelectronics, especially in green-blue-violet-UV light emitting devices. However the quality of GaN is still under development and requires continuous research. One of the difficulties related to this material is determination of hole concentration in p-type doped GaN. While for n-type doped GaN the free carrier concentration can be easily evaluated by Hall measurements. In the case of p-type GaN electrical experiments are very difficult because of problems with ohmic contacts.

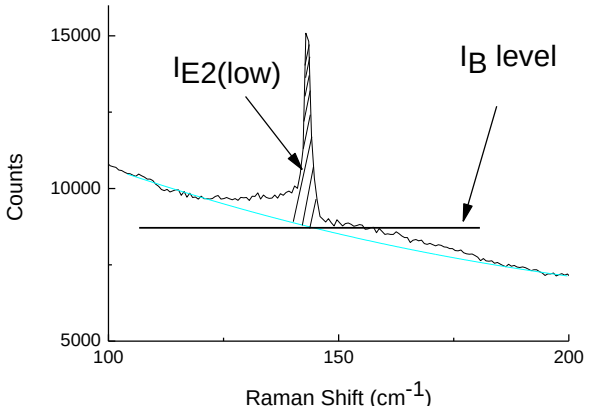

Figure 1. Example Raman spectrum of p-type GaN with showed $I_{E2\ (low)}$ an I_B level.

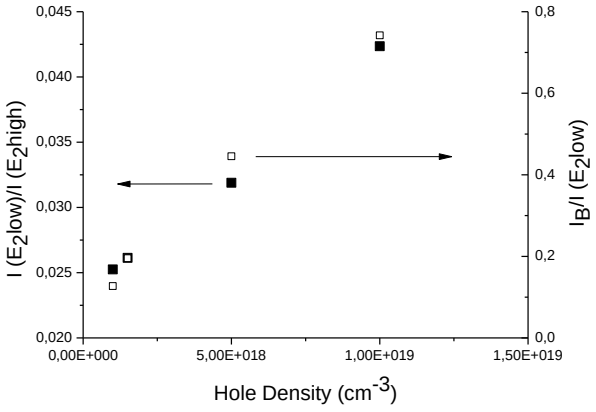

Figure 2. $I_{E2(low)}/I_{E2(high)}$ and $I_B/ I_{E2(low)}$ ratios depending on the concentration of p-type GaN.

In this communication we present a way of determination of the free hole concentration in p-type GaN using Raman spectroscopy. The idea of the experimental procedure is based on the fact that due to p-type doping a broad Raman band, caused by inter-valence-band transition, occurs in the low frequency region of the spectrum (see Fig. 1). Such inter-valence-band transitions were already measured not only in GaN [1] but also in Si [2] and GaAs [3]. It was already found, that the ratio of intensity of this band, measured at the energy of E_2(low) phonon mode, to the integrated intensity of E_2 (low) mode, scales with the free hole concentration [1], which is qualitatively reproduced in our experiments (see Fig. 2). However, our experiments show, that another correlation between the integrated intensities of E_2 (low) and E_2 (high) phonon modes occures.
The observed behavior of the ratio $I_{E2(low)}/I_{E2(high)}$ in the p-type GaN was not reported in the literature yet and requires further study to be explained.

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