# Comment on “Shallow donors in GaN studied by electronic Raman scattering in resonance with yellow luminescence transitions” [Appl. Phys. Lett. 69, 1276 (1996)]

H. Siegle, I. Loa, P. Thurian, L. Eckey, A. Hoffmann, I. Broser, and C. Thomsen
*Institut für Festkörperphysik, Technische Universität Berlin, 10623 Berlin, Germany*

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In a recent letter, Ramsteiner *et al.* reported the observation of electronic Raman transitions in GaN grown on GaAs.[1] The excitation curves of these Raman spectra were in resonance with the maximum of the broad luminescence of their samples at 2.2 eV, from which the authors deduced the observation of electronic states of shallow donors involved in the yellow luminescence. We present here evidence which makes the proposed direct link to the yellow luminescence doubtful.

We performed Raman-scattering experiments[2] on GaN layers on different substrates. One series of samples was grown on GaAs by molecular beam epitaxy (MBE) and two other series on sapphire by metal-organic chemical-vapor deposition (MOCVD) and by hydride vapor phase epitaxy (HVPE). While the samples grown on sapphire exhibit a strong yellow luminescence with an intensity maximum at 2.2 eV, most of the layers grown on GaAs show a rather broad luminescence ranging from the donor-acceptor-luminescence region (~3.1 eV) to less than 1.8 eV (Fig. 1).

The most striking observation we made was that the additional peaks reported by Ramsteiner *et al.* were present *only* in spectra taken from samples grown on GaAs. Samples grown on sapphire did not exhibit these features, although they show a much stronger yellow luminescence (see Fig. 1). Therefore, a direct link to the yellow luminescence as proposed by Ramsteiner *et al.* appears doubtful. We found the additional Raman modes also in purely cubic layers (as evidenced by the weakness of the $E_2$ mode) contradicting the assignment by Ramsteiner *et al.* of some modes to the cubic and some to the hexagonal modification of GaN.

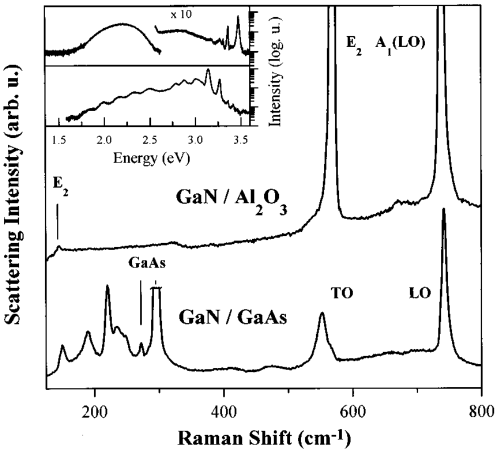

FIG. 1. Low-temperature (4.2 K) Raman spectra of a GaN layer grown on sapphire (upper curve) and on GaAs (bottom curve) obtained with 514.5 nm (2.41 eV) excitation. The inset shows the corresponding photoluminescence spectra after excitation at 325 nm (3.81 eV).

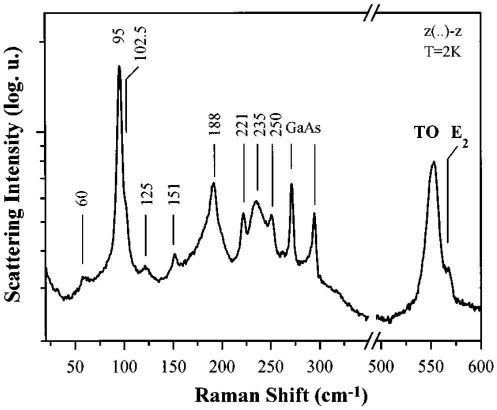

FIG. 2. Low-temperature (2 K) Raman spectrum of a GaN layer grown on GaAs. Excitation was at 514.5 nm (2.41 eV).

Furthermore, we have extended the range of our spectra to lower Raman shifts than those reported in Ref. 1, and we find an additional, quite pronounced mode at 95 $\mathrm{cm}^{-1}$ as well as modes at 60, 102.5, 125, and 250 $\mathrm{cm}^{-1}$ that were not reported in Ref. 1 (Fig. 2). All these lines show a similar resonance behavior to the one described in Ref. 1, although the activation energies (as determined with the formula used in Ref. 1) obtained from the temperature dependences of the peaks differ somewhat, varying from $21\pm4$ (peak at 235 $\mathrm{cm}^{-1}$) to $30\pm5$ meV (peak at 250 $\mathrm{cm}^{-1}$) compared to 32 meV reported in Ref. 1. Since all peaks have the same Raman excitation spectrum, it is unlikely that they are of fundamentally different origin from the peaks reported in Ref. 1. These low-energy peaks, however, do not fit the model published by Ramsteiner *et al.*, in which hydrogenlike transitions between the electronic states of a shallow donor were involved.

In summary, we have presented evidence that the simple hydrogenlike model of electronic transitions cannot explain all additional Raman peaks observed at low energies in GaN grown on GaAs by MBE. Instead, we believe that either N impurities in GaAs or As defects in GaN are likely to be their origin. There is no direct link, in our opinion, to the yellow luminescence in GaN.

[1] M. Ramsteiner, A. J. Menniger, O. Brandt, H. Yang, and K. H. Ploog, Appl. Phys. Lett. **69**, 1276 (1996).

[2] H. Siegle, P. Thurian, L. Eckey, A. Hoffmann, C. Thomsen, B. K. Meyer, H. Amano, I. Akasaki, T. Detchprohm, and K. Hiramatsu, Appl. Phys. Lett. **68**, 1265 (1996).

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