Photoluminescence and photoconductivity studies of reactive-ion-etched GaN on SiC substrates

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We have investigated the properties of variously etched GaN films grown on SiC using photoluminescence (PL) and photoconductivity (PC) spectroscopy. Such experiments are useful for revealing information on defects introduced by etching that can degrade performance of electrical and optical devices. For example, our photoluminescence studies of sapphire-substrate GaN films have correlated defect-related blue and yellow luminescence bands with etch-induced damage [1,2]. Successful development of nanostructured GaN-based optoelectronic devices will require sophisticated understanding and control over of etch-induced defects.

The samples investigated here were obtained from a nominally undoped wafer of 0.5 micron thick GaN grown on SiC. The material exhibited n-type conductivity with a reported carrier density of $3x10^{17}cm^{-3}$. Several samples were reactive-ion-etched with various gases and dc biases using techniques described elsewhere [1].

The low temperature spectra of an unetched sample are shown in Fig. 1. The PL spectrum is dominated by emission at 3.445eV, that is most likely related to D^0X. This energy is different from that reported by, for example DeVittorio et al [3] who observed D^0X at 3.452eV. Such a shift is not unreasonable for material from different sources however comparison with the PC data makes it unlikely that the peak observed in PL is simply D^0X. Apparent in Fig. 1 is that the lowest feature in the PC spectrum lies 15 meV higher in energy than the low energy peak observed in the PC spectra. At high temperatures the PL spectra exhibit an additional feature that correlates with the position of the low energy line in the PC spectra, providing crucial support for our identification of the observed spectral features.

Fig. 2 shows PC spectra for 2 samples etched with N_2 and the mixture SF_6/N_2, along with the data from the unetched sample. All samples exhibit the same two peaks although with very different intensities as can be seen by the relative noise. The origin of these peaks will be discussed with reference to previous reports of the energies of the A_1, B_1 and C_1 excitons and the 2s energy level of the A exciton. [4]

The PL spectra also reveal that etching with either of the gases reduces the intensity of the main emission band. Correlated with the PC data, the emission from the N_2 etched sample is weakest. As the PC features are not defect related, the generation of e-h pairs in the etched samples should be similar. Thus the differences in PC signals can be correlated to the carrier lifetimes and subsequently the presence of traps and defects. It is apparent that for both the N_2 and SF_6/N_2 etched samples, defects are produced that trap carriers thus reducing the PC signal. Furthermore these defects are apparently

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unrelated to the donors associated with the D^0X emission as the N_2 sample has both the smallest PC and PL signals. A smaller concentration of defects for the SF_6/N_2 sample is consistent with this etchant having a greater ability to remove GaN material, thus producing a thinner damaged layer.

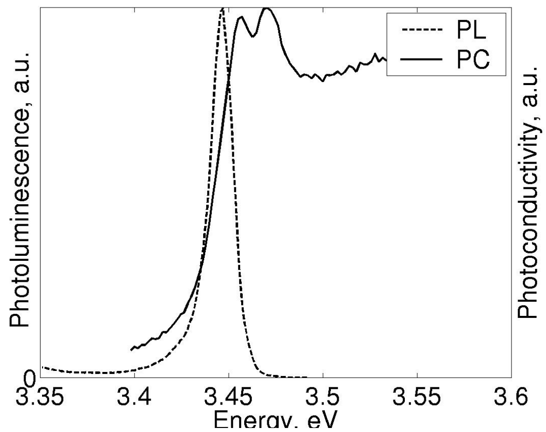

Fig. 1. Photoluminescence and photoconductivity spectra from an unetched GaN sample at 25K. At higher temperatures an additional feature becomes apparent in the PL spectra at the same energy as the low energy peak in PC.

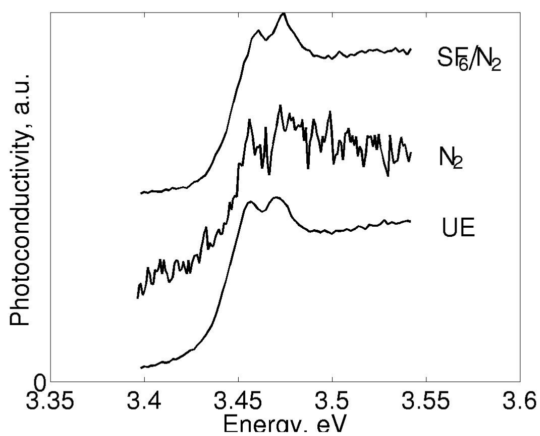

Fig. 2. Photoconductivity spectra from SF_6/N_2 and N_2 etched samples, together with data from an unetched sample. Similar features are observed in each spectrum, but the differing signal levels indicate introduction of defects during the etching process.

References

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