Response to "Comment on Influence of indium tin oxide thin-film quality on reverse leakage current of indium tin oxide/*n*-GaN Schottky contacts [Appl. Phys. Lett. 90, 046101 (2007)]"

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On receiving the Comment of Lin *et al.*[1] on our paper published in the Applied Physics Letters,[2] which suggested oxygen vacancies as the defect responsible for the observed increased S parameter, we provide the following reply.

Lin *et al.* suggested that the positron annihilation spectroscopy (PAS) technique could not be applied to the study of oxygen vacancies due to their positive charge (V_{O}^{+3}).

We express our gratitude to Lin *et al.* for pointing this out to us, and indeed admit that we did not discuss it in Ref. 2. Nevertheless we still are of the opinion that the most likely explanation for the increase of S parameter is the trapping into V_{O} defects. The primary reason is still that the S parameter does reduce under the presence of oxygen, but as Lin *et al.* point out there are good reasons to suppose that the V_{O} defect is in a positively charged state. We certainly agree on this point. We must, however, draw attention to the electrical properties of our indium tin oxide (ITO) samples. The carrier concentration n and the mobility μ lie between $(1-6)\times 10^{21}\ \mathrm{cm}^{-3}$ and $2-11\ \mathrm{cm}^2/\mathrm{V\,s}$, respectively. For such low mobility, the effect of neutral impurity scattering should be considered as Tahar *et al.*[3] mention. For such high concentrations, it is well known that Fermi level E_F moves into the conduction band as shown by Fan and Goodenough.[4] The occupation probability of oxygen vacancies by an electron is very high because the energy level $E_{V_{\mathrm{O}}}$ of oxygen vacancies is below E_F.[4] The ITO is becoming metallic in nature. Typical metals have electron concentration of $\sim 10^{22}\ \mathrm{cm}^{-3}$ for which the Thomas-Fermi screening length is given by[5]

$$\lambda_{\mathrm{TF}} = \left(\frac{3\hbar^2\varepsilon_0}{2me^2}\right)^{1/2}\left(\frac{\pi}{3n}\right)^{1/6},$$

where ε_0 is the dielectric constant of vacuum, m is the electron mass, e is the electron charge, and n is electron density. Calculating the screening length in a metal gives 0.1 nm, and for the $10^{21}\ \mathrm{cm}^{-3}$ concentration of ITO this only increases a little to ~ 0.14 nm. Thus for ITO as well as metals the electric field produced by any positive center is negligible outside the defect. This is why in metals there is no effect of positron trapping rate being dependent on charge. Likewise in ITO we argue that the Thomas-Fermi screening will neutralize the natural positive charge on the V_{O} defects and allow efficient positron trapping.

In summary, while Lin *et al.* suggested that the PAS technique could not be applied to the study of oxygen vacancies in the ITO thin films due to their positive charge (V_{O}^{+3}), we think that their comments have no influence on the main conclusions given in our letter.

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