Positron Annihilation studies of Various doped β-Ga_2O_3 Single Crystals with a Variable Energy Positron Beam

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Growth of Czochralski and vertical gradient freeze grown doped β-Ga_2O_3 (different doping levels of Zr, Mg) will be presented with support from theory [1]. Positron Annihilation Spectroscopy (PAS) were used to study vacancy, vacancy-donor pairs and clusters. β-Ga_2O_3 shows promise as an ultra-wide bandgap transparent semiconducting single crystalline material with n-type conductivity. UV/VIS/NIR optical spectroscopy was used to measure the bandgap and qualitatively compare free carrier concentration between crystals with varying concentrations of dopants. Hall effect, four-point contact current-voltage (I-V) and capacitance-voltage (C-V) measurements are used to measure electron mobility, carrier concentration, resistivity1, and dopant activation energy.

Several possibilities for this deep level could be a deep acceptor such as gallium vacancies or Fe or Ir impurities (Fe and Ir have been observed with SIMS with no standards), or a deep donor such as an oxygen vacancy. Contact I-V measurements show a resistivity of down to 0.02 Ω-cm and an activation of 5-13 meV will be related to the positron results. Hall effect measurements show carrier density on the order of 10^{17} to 5×10^{18} cm^{-3} and a mobility of approaching 100 cm^2/Vs [1]. The relationship between electron mobility and charge concentration was investigated with respect to vacancies through PAS. Samples throughout the crystal and melt were measured to understand how the growth process impacted the growth results. Tailoring the doping concentration and growth environment is the key to reducing the intrinsic defects and impurities and improving electron mobility within Zr:Ga_2O_3. Zirconium-doped β-Ga_2O_3 shows promise as a high free carrier concentration material with high mobility, requiring future work on reducing compensating defects.

References

[1] Muad Saleh, Arkka Bhattacharyya, Joel B. Varley, Santosh Swain, Jani Jesenovec ,Sriram Krishnamoorthy, Kelvin Lynn to be published

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