The electronic structure of n-type doped Ga_2O_3 homo-epitaxial thin films

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Ga_2O_3 is emerging as a promising ultra-wide bandgap semiconductor of potentials for high-power electronics and solar-blind ultraviolet photodetectors. It is highly desirable to dope it with controllable carrier concentrations for different purpose of device applications. This talk reports the realization of n-type doping of Ga_2O_3 homo-epitaxial thin films with Si or Sn with carrier concentrations ranging from 2×10^{16} up to 2.6×10^{20} cm^{-3} grown by pulsed laser deposition (PLD) and molecular beam epitaxy (MBE). Combined photoemission spectroscopy and DFT calculations were used to elucidate insights on the doping mechanisms and evolution of electronic structures. Si was found as a superior dopant compared to Sn, because Si 3s has a lower energy and thus very small perturbation to the Ga 4s derived conduction band minimum (CBM), while Sn 5s mix stronger with the CBM. An in-gap defect state was observed at the 1.2 eV the top of valence band maximum for the Sn-doped Ga_2O_3 film. The in-gap state acts as self-compensating centers affecting the overall doping efficiency and mobility. Furthermore, photoemission spectroscopic study also reveals an upward surface band bending existing at the surface region of Sn doped Ga_2O_3 films. The identification of the in-gap state and surface upward band bending have significant implications for understanding the doping mechanisms in Ga_2O_3 and its electronic device applications.

References

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