EDITORIAL

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Preface to Special Issue on Towards High Performance Ga_2O_3 Electronics: Epitaxial Growth and Power Devices (Ⅰ)

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There is currently great optimism within the electronics community that gallium oxide (Ga_2O_3) ultra-wide bandgap semiconductors have unprecedented prospects for eventually revolutionizing a rich variety of power electronic applications. Specially, benefiting from its ultra-high bandgap of around 4.8 eV, it is expected that the emerging Ga_2O_3 technology would offer an exciting platform to deliver massively enhanced device performance for power electronics and even completely new applications. High-quality Ga_2O_3 thin films are critical and yet demanding in the quest for power electronic devices with desired performance. Therefore, with the advent of Ga_2O_3-enabled power device systems, effective epitaxy techniques that can achieve the scalable synthesis of high-quality Ga_2O_3 thin films are urgently required.

To outline the latest advances along with the opportunities and challenges of Ga_2O_3 technologies, we organised a Special Issue on “Towards high performance Ga_2O_3 electronics”, which will be published in two consecutive issues on *Journal of Semiconductors*. This issue features a collection of cutting-edge advances focused on thin film epitaxy techniques for Ga_2O_3 semiconductors and their application in innovative power electronic devices, consisting of six research articles, two timely reviews and one Comments & Opinions. W. Tang and co-workers[1] report the homoepitaxial growth of Si-doped β-Ga_2O_3 thin films on semi-insulating (100) β-Ga_2O_3 single crystal substrates through metalorganic chemical vapor deposition (MOCVD) method. With careful optimization of growth conditions, high-quality epitaxial β-Ga_2O_3 layers with adjustable Si-doping concentration were realized using the MOCVD epitaxy approach. Outstanding electronic properties including high electron mobility and low contact resistance are further shown in this work, suggesting high-performance electronic devices based on the Si-dope β-Ga_2O_3 films. W. Wang and co-workers[2] discuss the epitaxial relationship and electronic behaviour of α-Ga_2O_3 thin films depending on the crystal orientation of the sapphire substrates. Physical properties including crystalline structure, optical bandgap and electrical conductivity were thoroughly investigated for α-Ga_2O_3 thin films with different crystal orientations. Oxygen vacancy level variation of differently-oriented α-Ga_2O_3 thin films has been proposed as the origin for the observed difference in physical properties. X. Wang and co-workers[3] experimentally show a mist-CVD-based rapid epitaxy technique for the fabrication of high-quality α-Ga_2O_3 films. Large-scale and uniform α-Ga_2O_3 thin films up to 2-inch were demonstrated to be grown on sapphire substrates. Related thin film growth mechanisms were investigated by performing comprehensive crystal structure characterizations. L. Cheng and co-workers[4] present the study of the hetero-epitaxy of β-Ga_2O_3 thin films on sapphire substrates using the carbothermal reduction method. Optimized growth parameters were experimentally investigated and obtained for the high-quality β-Ga_2O_3 epitaxial thin films. The authors’ results indicate that the carbothermal reduction method could be a viable technique for β-Ga_2O_3 thin film deposition. Beyond the application of Ga_2O_3 on electronic devices, L. Li and co-workers[5] report their recent progress on Sn-doped Ga_2O_3 thin film enabled high-performance solar-blind photodetectors. The effect of different post-annealing gas conditions was investigated for radio frequency magnetron sputtering prepared Sn-doped β-Ga_2O_3 films. Y. Wang and co-workers[6] developed a CVD method for centimetre-scale Ga_2O_3 microwire growth and demonstrated photodetectors based on the fabricated Ga_2O_3 microwires. They show that microwires of single crystalline Ga_2O_3 can be obtained reaching up to 1 cm in length. Leveraging the high crystal quality, Ga_2O_3 microwire-based metal-semiconductor-metal photodetectors were achieved showing excellent solar-blind photodetection behaviour. B. Li and co-workers[7] present a timely account of recent advances in enhancement-mode β-Ga_2O_3 enabled field-effect transistors (E-mode FETs), covering the material growth, device fabrication and typical device properties. It is concluded that β-Ga_2O_3-based E-mode FETs, as a promising device concept, could drive exciting innovations for power electronics. The authors also discussed the key challenges and future development of β-Ga_2O_3-based E-mode FETs. Nickel oxide (NiO) has been identified as a promising wide-bandgap p-type semiconductor complementary to the n-type Ga_2O_3. X. Lu and co-work-

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ers[8] summarize and discuss recent advances and challenges of NiO/Ga_2O_3 heterojunction enabled power electronic devices. Recent progress regarding the construction and characterization methods as well as the device technology for NiO/Ga_2O_3 heterojunctions are critically surveyed. Furthermore, future challenges and opportunities of NiO/Ga_2O_3 heterojunction-based power electronic devices are discussed. In the Comments & Opinions, G. Han and co-workers[9] provide an insightful discussion on the status quo and future opportunities of the heterogeneous integration technologies for Ga_2O_3 thin film-based power devices. Building Ga_2O_3 power devices urgently requires an efficient thermal management strategy due to the intrinsically low thermal conductivity of the Ga_2O_3 itself, which thus inspires new ways to realize "cool" devices. By critically surveying the existing technologies that can address the thermal management challenge of Ga_2O_3 power devices, the authors highlight the ion-cutting based heterogeneous integration as a promising approach towards scalable production of high-performance power devices with high thermal stability.

We are delighted to share these timely reviews and exciting research results on the field of Ga_2O_3 electronics with the readership of *Journal of Semiconductors*. We hope that this Special Issue will provide the readers with an overview of the recent progress, opportunities and challenges of Ga_2O_3 thin film epitaxy technology and power devices. We would like to thank all the authors for their great contributions to this Special Issue. We are also grateful to the editorial and production staff of *Journal of Semiconductors* for their warm help.

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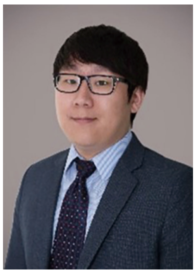

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