EDITORIAL

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Preface to Special Issue on Towards High Performance Ga_2O_3 Electronics: Power Devices and DUV Optoelectronic Devices (Ⅱ)

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Gallium oxide (Ga_2O_3) has garnered world-wide attention as an ultrawide-bandgap semiconductor material from the area of power electronics and DUV optical devices benefiting from its outstanding electronic and optoelectronic properties. For one thing, since Ga_2O_3 features high critical breakdown field of 8 MV/cm and Baliga's figure of merit (BFOM) of 3444, it is a promising candidate for advanced high-power applications. For another thing, due to the bandgap directly corresponding to the deep-ultraviolet (DUV) region, Ga_2O_3 is widely used in DUV optoelectronic devices.

To outline the latest advances along with the opportunities and challenges of Ga_2O_3 technologies, we organized a Special Issue on "Towards high performance Ga_2O_3 electronics", which will be published in two consecutive issues on *Journal of Semiconductors*. The first 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. This issue looks at the focus topic on power devices and DUV optoelectronic devices for Ga_2O_3 semiconductors and the application in advanced high-power electronic devices, consisting of eight research articles, one timely review and one Comments & Opinions.

Currently β-Ga_2O_3 is therefore mainly used in unipolar devices because of the challenge to obtain stable p-type β-Ga_2O_3, including Schottky barrier diodes (SBDs) and field-effect transistors (FETs).

β-Ga_2O_3 SBDs have been intensively studied and undergone rapid progress since the early 2010s and have achieved remarkable results. Interpreting and understanding the temperature dependent β-Ga_2O_3 SBDs characteristics and the dominate conduction mechanisms are critical for improving SBD performance.

M. Labed and co-workers[1] analyze the W/β-Ga_2O_3 Schottky barrier diodes deposited by confined magnetic field-based sputtering (CMFS) at different operation temperatures. Temperature dependent SBD parameters including the Schottky barrier height, ideality factor, the series and on-resistances are shown in this work. The interfacial dislocation extracted from the tunneling current was further presented, suggesting the domination of tunneling through dislocation in the transport mechanism.

Nevertheless, the absence of p-type Ga_2O_3 is a main difficulty for the bipolar devices. To conquer this challenge, a natively p-typed oxide of NiO is proved to be greatly suitable for β-Ga_2O_3 power devices.

T. Han and co-workers[2] report high-performance NiO/β-Ga_2O_3 vertical heterojunction diodes (HJDs) with double-layer junction termination extension (DL-JTE) consisting of two p-typed NiO layers with varied lengths. Outstanding electronic properties including high breakdown voltage, low specific on-resistance and a power figure-of-merit (PFOM) of 5.98 GW/cm^2 are presented in this work, indicating that the DL-JTE structure provides a promising approach towards high-performance Ga_2O_3 HJDs.

Z. Jiang and co-workers[3] experimentally show the instability mechanisms for a NiO/β-Ga_2O_3 heterojunction-gate field effect transistor (HJ-FET) under different gate stress voltage ($V_{G,s}$) and stress times (t_s), it is identified that there are two different degradation mechanisms of the devices under negative bias stress (NBS), offering an important theoretical guide to study the reliability of NiO/β-Ga_2O_3 heterojunction devices in power electronic applications.

To fully utilize the application potential of β-Ga_2O_3, the large-area structures are needed to sustain a high on-state current for practical applications and yet demanding in the quest for the thermal effect and circuit applications.

X. Zhou and co-workers[4] demonstrate a multi-finger MOSFET with output current reach to 0.5 A. To critically investigate the self-heating effect, the authors highlight the generation and dissipation actions by analyzing the electrical characteristics, heat dissipation of the device and the relationship between device temperature and time/bias.

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W. Guo and co-workers[5] present superb large-area vertical β-Ga_2O_3 SBDs with a Schottky contact area of 1 × 1 mm^2 and achieve a high-efficiency DC–DC converter based on the device. Superior electronic properties including outstanding forward characteristics, low on-resistance (R_{on}), high breakdown voltage and a conversion efficiency of 95.81% are presented in this work, indicating the great potential of Ga_2O_3 SBDs and relevant circuits in power electronic applications.

Ga_2O_3, as an ultra-wide bandgap semiconductor with their bandgap directly corresponding to the DUV region, provides a new scheme to deliver massively enhanced device performance for filter-free DUV photodetectors. Furthermore, the persistent photoconductivity (PPC) effect exhibited by its amorphous counterpart suggests new applications in neuromorphic computing.

J. Tao and co-workers[6] demonstrate a high-performance ultraviolet-visible (UV-VIS) photodetector based on a TiO_2@GaO_xN_y-Ag ternary heterostructure. Excellent optoelectronic characteristics, including superb responsivity and detectivity particular, could be mainly attributed to the synergistic effect of the type-Ⅱ band structure of the metal–semiconductor–metal heterojunction and the plasmon resonance effect of Ag.

Ga_2O_3 based flexible heterojunction type DUV photodetectors show excellent solar blind photoelectric performance which makes them ideal for use in intelligent wearable devices. C. Wu and co-workers[7] present a novel self-healing and self-powered photodetector based on PEDOT: PSS/Ga_2O_3 active layer and a hydrogel substrate. Remarkable recovery capability and the photodetector's superior photoelectric performance were achieved showing new possibilities to develop wearable and intelligent electronics in the future.

Optoelectronic synapse and neuromorphic computing propose a new structure that differs from conventional von Neumann architecture, offering the benefits of low power consumption, high transmission rate, wide bandwidth and security. R. Li and co-workers[8] demonstrate an homojunction-based multi-functional optoelectronic synapse (MOLS) with an Al/Ga_2O_3(oxygen-deficient)/Ga_2O_3(oxygen-rich)/ITO vertical structure and modulated with dual-band wavelength illumination to mimic biological synaptic behaviors such as PPF and SNDP. The MOLS exhibited the performances of associative learning and logic gates, paving the way for in-sensor and parallel computation in neural morphology devices.

Y. Zhang and co-worker[9] summarize and discuss the anisotropic properties and applications of β-Ga_2O_3, anisotropic optical properties including optical bandgap, Raman and photoluminescence characters are comprehensively reviewed. In addition, the anisotropy in electron mobility and affinity are discussed. Finally, the applications, especially polarization photodetectors, based on β-Ga_2O_3 were summarized comprehensively.

In the Comments & Opinions, G. Xu and co-workers[10] provide an insightful discussion on the development of vertical β-Ga_2O_3 power electronics covering various surface/interface engineering, diverse edge termination and quasi-inversion vertical transistor. The existing problems of gallium oxide power devices including high defect density and severe interface damage of large area devices, lack of p-type doping and low thermal conductivity are further shown in this article. Building the current blocking layers (CBLs) formed by oxygen annealing/N-implantation/*in situ* epitaxy can minimize punch-through current and improve breakdown voltage of β-Ga_2O_3 transistors, the authors highlight the U-MOSFET may be the way out for β-Ga_2O_3 power transistors.

We are excited to share these timely reviews and advanced research results on the field of Ga_2O_3 electronics with the readership of Journal of Semiconductors. We sincerely hope that this Special Issue will provide the readers with a meaningful and profound overview of the recent progress, opportunities and challenges of power devices and DUV optoelectronic devices for Ga_2O_3 semiconductors. 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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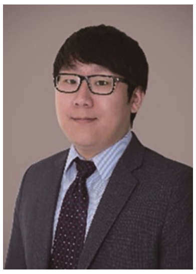

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