4th Intensive Discussions on Growth of Nitride Semiconductors

4th Intensive Discussion on Growth of Nitride Semiconductors (IDGN-4), held on November 18-20, 2018, is aimed to analyze the status quo, and to find the direction to take in the future and the problems that need to be solved in the field of crystal growth of nitride semiconductors. To achieve these, the number of participants is limited to 50 persons including researchers from abroad, and the straightforward discussions are greatly encouraged among the selected professionals. Participants are expected to have common understandings in the current technologies and to find out the way to solve problems in the crystal growth. IDGN-4 consists of 8 technical sessions, 23 invited speakers, and 41 participants. IDGN-4 covers wide range of topics such as GaN vertical power devices, GaN-based high electron mobility transistors, device processes, defect properties, epitaxial growth technologies, bulk growth technologies, and characterization of defects.

IDGN-4 was held at Auditorium of Institute for Materials Research in Katahira campus, Tohoku University on November 18-20, 2018. About 50 specialists in the field of nitride semiconductors participated in this workshop including foreign researchers. The leading researchers in the fields of electronic devices, the crystal growth, and the characterization for devices presented each current status, and discussed on technical issues each other.

Staring from the vapor-phase growth of GaN by H. P. Marcus and J. J. Tietjen in 1969, nitride LEDs and LDs have been widely used as solid state lighting for energy saving and high-density recording such as Blu-ray, since blue LEDs became commercially available in 1996. Nitride transistors with high-frequency and high-power will come to realization in the near future. Thus, the device application has progressed in a variety of fields; however, the crystalline quality is still poor in comparison with conventional III-V semiconductors such as GaAs and InP. For the future development in high efficiency, long device-lifetime, and the expansion of application, it is indispensable to improve the crystalline quality and to control the crystal characteristics [1].

The previous workshops (IDGN-1, 2, and 3) held in 2012, 2014, and 2017 provided us the opportunity to share the most recent achievements and to discuss the technical issues on the crystal growth and device applications of nitrides. The purpose of the present workshop was to analyze the status quo, and to find the direction to take in the future and the problems that need to be solved in the field of high power and high breakdown voltage transistors, high frequency transistors [2], the epitaxial growth and the process technology for transistors [3]. Participants had common understandings in the current technologies and found out the way to solve problems in the sessions of growth, characterization, theory, and electronic Devices. In the workshop, some selected topics were presented at the beginning of each session, for example by Prof. Srabanti Chowdhury from University of California, Dr. Leo Schowalter from Hexatech/Asahi Kasei in USA, and Dr. Malgorzata Iwinska from Institute of High Pressure Physics in Poland. The participants voluntarily presented their data, which were followed by deep and -intensive discussion. This style is not common but brought us the significant outcome.

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References

[1] T. Tanikawa, K. Ohnishi, M. Kanoh, T. Mukai, and T. Matsuoka, Appl. Phys. Express **11**, 031004 (2018).

[2] K. Prasertsuk, T. Tanikawa, T. Kimura, S. Kuboya, T. Suemitsu, and T. Matsuoka, Appl. Phys. Express **11**, 015503 (2018).

[3] K. Ohnishi, M. Kanoh, T. Tanikawa, S. Kuboya, T. Mukai, and T. Matsuoka, Appl. Phys. Express **10**, 101001 (2017).

Fig. 1 Participants: selected professionals.

Keywords: nitride, crystal growth, electronic material
Takashi Matsuoka (Physics of Electronic Material, IMR)
E-mail: matsuoka@imr.tohoku.ac.jp
Workshop Website http://www.matsuoka-lab.imr.tohoku.ac.jp/?IDGN-4

IDGN-4 Program

November 18 (Sun)

Welcome Reception	Barbaresco, Sendai	18:00-20:00

November 19 (Mon)

Opening	Auditorium, Bldg. 2, IMR, Tohoku Univ.	9:00-9:15

Electronic Devices I	Auditorium, Bldg. 2, IMR, Tohoku Univ.	9:15-10:45

- ED-I-1 9:15-9:45
  Vertical GaN Power Devices and Automotive Application
  Tetsu Kachi (Nagoya Univ., Japan)

- ED-I-2 9:45-10:15
  A discussion on Vertical GaN Device Variations and their Applicability
  Srabanti Chowdhury (UC Davis, USA)

- ED-I-3 10:15-10:45
  Fabrication and Characterization of Vertical GaN MOSFETs
  Masaaki Kuzuhara (Fukui Univ., Japan)

Break 10:45-11:15

Electronic Devices II

Auditorium, Bldg. 2, IMR, Tohoku Univ. 11:15-12:15

- ED-II-1 11:15-11:45

  Mapping of Metal/Semiconductor and Semiconductor/ Semiconductor Interfaces Using Scanning Internal Photoemission Microscopy

  Kenji Shiojima (Fukui Univ. Japan)

- ED-II-2 11:45-12:15

  Defect Electronics in SiC for High-Voltage Power Devices

  Tsunenobu Kimoto (Kyoto Univ., Japan)

Lunch 12:15-13:45

Growth I

Auditorium, Bldg. 2, IMR, Tohoku Univ. 13:45-14:45

- GR-I-1 13:45-14:15

  Growth of GaN-Based Semiconductors on h-BN Release Layers

  Yasuyuki Kobayashi (Hirosaki Univ., Japan)

- GR-I-2 14:15-14:45

  Development of two-inch AlN substrates and Pseudomorphic AlGaN Technology for Optoelectronic, Power, RF, and High Temperature Applications: the Better Wide Bandgap Semiconductor Technology

  Leo Schowalter (Crystal IS/Asahi Kasei, USA)

Growth II

Auditorium, Bldg. 2, IMR, Tohoku Univ. 14:45-16:15

- GR-II-1 14:45-15:15

  GaN Bulk Crystals by Hydride Vapor Phase Epitaxy for Power Devices

  Kazuyuki Tadatomo (Yamaguchi Univ., Japan)

- GR-II-2 15:15-15:45

  Influence of different dopants on the properties of bulk GaN

  Malgorzata Iwinska (UNIPRESS, Poland)

- GR-II-3 15:45-16:15

  Recent progress of acidic ammonothermal growth of GaN

  Shigefusa F. Chichibu (Tohoku Univ., Japan)

Break 16:15-16:45

Theory

Auditorium, Bldg. 2, IMR, Tohoku Univ. 16:45-18:15

- TH-1 16:45-17:15

  Ab Initio-Based Approach to Crystal Growth of Nitride Semiconductors: Alloy Composition and Impurity Concentration

  Yoshihiro Kangawa (Kyushu Univ., Japan)

- TH-2 17:15-17:45

  Recent Progress in Computational Materials Science for Growth of Nitride Semiconductors I

  Tomonori Ito (Mie Univ., Japan)

- TH-3 17:45-18:15
- **Recent Progress in Computational Materials Science for Growth of Nitride Semiconductors II: Analysis of Surfaces and Interfaces**

  Toru Akiyama (Mie Univ., Japan)

Banquet

The Westin Sendai 19:00-21:00

November 20 (Tue)

Electronic Devices III — Auditorium, Bldg. 2, IMR, Tohoku Univ. 9:00-10:30

- ED-III-1 — 9:00-9:30

  Prospective New Fuctionality of Monolithic GaN HEMT Integrated Circuits

  Yasuyuki Miyamoto (Tokyo Inst. of Tech., Japan)

- ED-III-2 — 9:30-10:00

  Low-Damage Etching for GaN-Based Electronic Devices Utilizing Photo-Electrochemical Reactions

  Taketomo Sato (Hokkaido Univ., Japan)

- ED-III-3 — 10:00-10:30

  Evaluation of Deep Levels in N-polar GaN Epitaxial Layers by Photo-Current DLTS: An Approach to Reveal the Self-Compensation Effect of Mg Doping in p-type GaN

  Hiroshi Okamoto (Hirosaki Univ., Japan)

- ED-III-4 — 10:30-11:00

  N-polar GaN/AlGaN Inversed High Electron Mobility Transistors

  Tetsuya Suemitsu (Tohoku Univ., Japan)

Break — 11:00-11:30

Growth III — Auditorium, Bldg. 2, IMR, Tohoku Univ. 11:30-12:15

- GR-III-1 — 11:30-12:00

  AlGaN/GaN Heterostructures Prepared by Regrowth of AlGaN on RIE-Treated GaN and their Device Applications

  Akio Yamamoto (Fukui Univ., Japan)

- GR-III-2 12:00-12:15

  Effect of Polarity of GaN Substrate on AlN Formation Temperature by Substitutional Reaction between Al Layer and GaN Substrate

  Marsetio Noorprajuda (Tohoku Univ., Japan)

Lunch 12:15-13:45

Characterization

Auditorium, Bldg. 2, IMR, Tohoku Univ. 13:45-15:45

- CR-1 13:45-14:15

  Dislocation Properties in Bulk GaN Substrates

  Akira Sakai (Osaka Univ., Japan)

- CR-2 14:15-14:45

  Revelation and Classification of Dislocations in GaN Single Crystal for Power Device Application

  Yongzhao Yao (JFCC, Japan)

- CR-3 14:45-15:15

  Novel Characterization Technique of Threading Dislocations in GaN Using Multiphoton-Excitation Photoluminescence

  Tomoyuki Tanikawa (Tohoku Univ., Japan)

- CR-4 15:15-15:45

  Interactions of Phonon, Electron, and Photon in Nitride Semiconductors

  Yoshihiro Ishitani (Chiba Univ., Japan)

Closing

Auditorium, Bldg. 2, IMR, Tohoku Univ. 15:45-16:00