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NEWSLETTER

An Initiative of ISAJ

Inside This Issue

From Editor's Desk

Greetings and a warm welcome to the first issue of ISAJ Newsletter in 2021!

We take this opportunity to wish you a healthy and productive life in 2021 and hope that you are taking all necessary precautions amid COVID-19 pandemic.

In this issue, we present you with two research articles and one event report on 11th Annual ISAJ Symposium-2020. The Research articles are on the study on low-temperature growth of III-Nitride materials by radical-enhanced metalorganic chemical and on the Augmented Reality and its future prospects. This issue also contains pictures of our 11th annual symposium held last year.

The article on the study of low-temperature growth of III-Nitride materials summarizes the epitaxial growth of III-nitride material by Radiacal Enhanced Metalorganic Chemical Vapor Deposition (RE-MOCVD). The RE-MOCVD is enhanced version of conventional MOCVD, which decreases the growth temperature using very high frequency plasma.

The Idea Brewing section of this issue outlines the upload-download asymmetry of service providers, which may lead to conflict between two emerging industries: Augmented Reality (AR) applications and streaming platforms. The article briefly discusses the evolution of AR and challenges it may face due to the gap between the uploading and downloading speeds.

ISAJ organized its 11th Annual Symposium on December 4th, 2020, using Zoom platform. The symposium theme was "Innovations in Science and Technology for New Issues and Challenges". It had a special interest session on COVID-19. There were around 100 participants, including 8 plenary speakers, 26 invited speakers and 24 student presenters. We present an overview of the Annual Symposium in the Event Report section of this issue.

We hope you would find the present issue of our Newsletter interesting. We look forward to receiving your feedback. Any suggestions/ideas for improving the upcoming newsletters are welcome.

Editorial Team

Low-Temperature Growth of III-Nitride Materials by Radical-Enhanced Metalorganic Chemical Vapor Deposition

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Postdoc Researcher at the Center for Low-Temperature Plasma Sciences, Nagoya University, Nagoya. He obtained his doctoral degree from the Department of Engineering Physics, Electronics, and Mechanics, Nagoya Institute of Technology in March 2014.
Dr. Frank Wilson has expertise on low-temperature plasma process, semiconductor materials and wafer process technology. Currently exploring III-nitride epitaxy using a novel technique called REMOCVD for optical and power devices.

Introduction

III-nitride semiconductors are attractive for optical and electronic device applications such as light emitting diodes (LEDs), laser diodes (LDs), and high electron mobility transistors (HEMTs). The band gaps of III-nitrides are large and direct. The band gap values are 0.7 eV for InN, 3.39 eV for GaN, and 6.2 eV for AlN. Band gaps from 0.7 eV to 6.2 eV can be obtained by suitable combinations in the AlGaInN system spanning the UV and visible ranges. Using AlGaN or GaN as the barrier and cladding layers and GaN or InGaN as active layers, quantum wells, and superlattices can be fabricated for modern devices.
GaN epitaxial layers grown on Si substrates by metal organic chemical vapor deposition (MOCVD) are widely investigated for low-cost fabrication of GaN devices. This method however has disadvantages as follows: (1) the V/III ratio is several thousands and the consumption of ammonia gas is so large that it prevails nearly the half of the production cost, (2) the growth temperature is higher than 1000 ℃ so that the decomposition of GaN is not negligible and increases the consumption of TMG, (3) since the growth temperature is so high that it is difficult to grow In containing nitrides, (4) because of the high growth temperature, when nitrides are grown on large diameter substrates, wafer breakage and bowing makes difficult its industrialization. In order to overcome these disadvantages, it is necessary to develop novel epitaxial growth methods which can replace the MOCVD method. In Nagoya University, we are developing a novel method called the radical-enhanced MOCVD (REMOCVD) method in order to decrease the growth temperature. We have developed the REMOCVD method with using VHF (very high frequency) plasma as shown in Fig. 1, and proved that the growth temperature of GaN, AlN, InN and AlInN can be largely decreased without using ammonia gas. These novel methods are promising for replacing the MOCVD method from the viewpoint of production cost and device performances. In this review, a summary of the epitaxial growth of III-nitride material by REMOCVD were discussed.

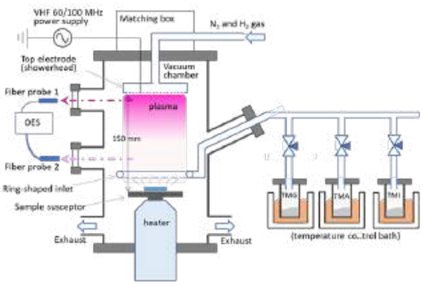

Fig. 1 Schematic of VHF-REMOCVD reactor

Figure 1 shows the experimental setup of our newly developed REMOCVD system consisting of a chamber having a capacitively coupled plasma source and a sample stage. The mixed gas of N2 and H2 was introduced through the showerhead of the top electrode as source gases which act as a precursor for group-V materials.

At the plasma discharge region, the generation of activated nitrogen species, including excited molecular and atomic nitrogen were observed by using optical emission spectroscopy (OES). Plasma was generated by applying plasma power with a very high frequency (VHF, 100 MHz) to the top electrode, distanced approx. 145 mm from the susceptor position. Metalorganic (MO) lines like trimethylgallium (TMG), was introduced inside the chamber. The TMG gas was supplied through a nozzle positioned above the substrate surface at the height of 7 mm. Here, we used remote plasma (RP), in which the TMG was flowed near the substrate surface to avoid the cracking of TMG around the plasma discharge region and avoids the generation of radical species of Ga* and CH*. The substrates were mounted on a carbon susceptor that was monitored by a thermocouple for controlling the substrate temperature. The TMG gas flow rate was controlled by a needle valve. The chamber pressure is controlled by the automatic pressure control valve without changing the flow rate of H_2 and N_2 gases.

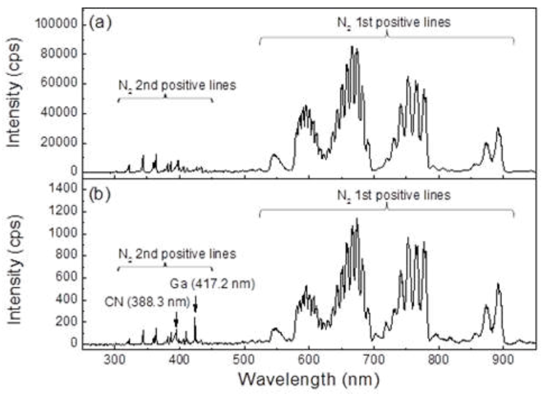

Fig. 2 Typical OES spectra at the (a) upper position and the (b) lower position from the REMOCVD system. VHF power is 1000 W and TMG flow rate is 0.05

Optical Emission Spectroscopy (OES)

The plasma provides various reactive nitrogen species such as grounded N atom (^{4}So), metastable N atom ($^2D^o$, $^2P^o$) and electronically excited N2 molecules ($A^3\Sigma u^+$), created by electron-collisions to the ground state of N_2 ($X^1\Sigma g^+$). Ammonia molecules are also created in the N_2 and H_2 plasma. A small amount of ammonia species was generated in the REMOCVD system 1, which is sufficient to supply N atom for the GaN growth. Figure 2 shows typical optical emission spectra measured at (a) the upper position of 10 mm below the showerhead and at the lower position (b) of 10 mm above the sample stage. The plasma was generated at 1000 W with introduction of 750 sccm N2 gas and 0.05 sccm TMG.

Lines for the 2nd positive series of N_2 ($C^3\Pi u \rightarrow B^3\Pi g$) in the wavelength range 300-450 nm and for the 1st positive series of N_2 ($B^3\Pi g \rightarrow A^3\Pi u^+$) in the wavelength range between 500 and 900 nm are clearly observed. In Fig. 2(b), a sharp peak at about 417.2 nm, attributed to neutral Ga atom transition $^5s^2S_{1/2} \rightarrow ^4p^2P^o_{3/2}$ and another peak at about 388.3 nm, attributed to CN, were appeared. These results indicate that the decomposition of TMG molecules occurs at the vicinity of the susceptor, depended on the VHF power, but not close to the showerhead electrode. To avoid the TMG decomposition at gas phase, it is essential to lower down the RF power. The homoepitaxial GaN was grown at 800 oC by REMOCVD and have been characterized by Scanning electron microscope (SEM), atomic force microscope (AFM), cross-sectional TEM, and X-ray diffraction as shown in Fig. 3.

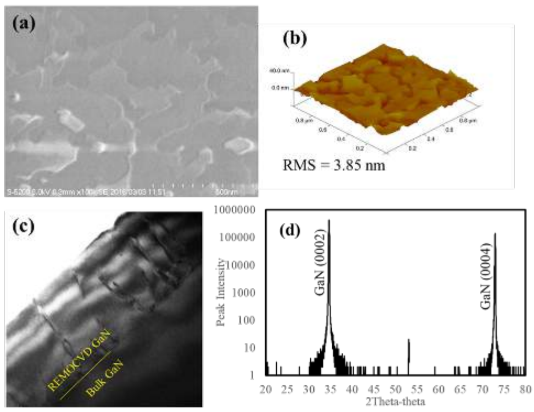

Fig. 3 Surface morphology by SEM and AFM, cross-sectional TEM, and XRC-2 theta-theta

The interface roughness was eliminated by N2/H2 plasma cleaning and high quality GaN with the XRC-FWHM of 100 arcsec was obtained.

Idea Brewing

Augmented Reality Industry and Online Streaming Platforms Are On a Collision Course

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His interests lie in the domain of Wireless Networks and Mobile Augmented Reality.

Because nothing in this world is fair, just, or egalitarian. Marx knew it better than most, but even a proletarian revolution is not going to fix the upload-download speed asymmetry [1] that is bound to trigger a new data war in the tech industry.

The AR Revolution

Augmented Reality (AR), unlike its completely immersive comrade "Virtual Reality (VR)", is poised to be a mobile paradigm. Simplistically put, AR will blend the real with the virtual on the go and enhance our view of reality.
To do so, any AR application will need four things: Live video of the real world, processing power to analyze the objects in the video, a knowledge database to enhance the real-world objects, and computational power to render the "augmented" view of the user's reality back to her.
Let's say, you are watching a game in a stadium or a sports arena. An AR application can look up additional information about a player. The AR app will use a camera to record the live game, detect and identify a player, dig up sports stats on her past performance, and display it on the user's view of the live game. Probably, on our very own smartphone that we can't live without and yet take for granted.
Even more appealing for the AR universe are the smart wearables, especially the smart eyeglasses which have been a work-in-progress for a decade. But if Mark Zuckerberg's talk at the Facebook developers' eighth annual conference [2] is any indication of the much-anticipated wave of AR-enabled technological transformation, the everyday wear smart-glasses could soon be a reality.
No more stopping to check the route on a map while riding a bicycle. Just put on your smart glasses and let an AR navigation app guide you hassle-free and handsfree. Pretty cool, huh.

Photo by Markus Spiske on Unsplash [Source: 1]

Image by Pexels from Pixabay [Source:2]

Well, perhaps I should not throw caution under the bus of optimism, so the "soon" still might be a few years away. "Better sooner than later, and better late than never," is pretty much how all progress in AR/VR spectrum can be defined.

AR is not a technology in itself, but a complex system of myriad technologies. Mobility makes it all the more complicated. But what really throws a wrench in the works is the "delay" in the four-step AR process, right from the moment the video is captured and until the "enhanced" view is rendered back to the user. We need that unhindered and uninterrupted high-speed data connectivity now!!

"5G is Coming," one might say. And unlike the "Winter" in the Game of Thrones that came with a whimper, 5G will come and revolutionize mobile data transmission. 5G, the next generation of cellular technology offers download speeds up to 300 Mb/s and upload speeds up to 50 Mb/s. The icing on the cake, however, is the high mobility to the users through a seamless service up to 100 kmph.

Yet, despite that promise, it is a bit late and a bit short of the bandwidth required for a flawless AR experience (Although that is a contentious topic to be discussed another day).

The Upload-Download Asymmetry

We are voracious consumers of digital media. From IGTV (video application of from Instagram) to Netflix, we are constantly entertaining ourselves with videos that are streamed at any place, at any time. Especially when we are mobile.

Such a tremendous amount of video data demand puts an enormous amount of pressure on the network service providers. Sample this, between 2012 and 2017 the global mobile data consumption increased 17 times [3], and by 2022 it will further increase 7 times while the data speed will only triple in this period. We will consume 930 exabytes of video data in 2022, which is hard to fathom yet true all the same.

We download, download, and download. Most of it is video because after all, video is the future. We lap up the content from Instagram influencers, Youtubers, to streaming platforms like Netflix.

So how do the network providers handle this download frenzy? Well, they split the total bandwidth or data speeds in favor of downloads. Uploads are generally slow, and quite often, annoyingly slow.

Attaching media to an email right up to its permissible upper limit can teach the virtue of patience even to the incorrigibly restless.

This current asymmetry in data speeds works to the advantage of streaming services. In fact, it is a self-propelling narrative-the demand for video encourages bandwidth asymmetry in favor of downloads, and greater download speeds nudge user-behavior towards downloading and streaming more video content.

Could be taught as a classic real-world example of the nudge theory in behavioral economics, if you ask me.

The AR Conundrum

AR is inherently upload-intensive and demands that the current asymmetry be turned on its head-figuratively and literally.

Let us consider a simple AR application that makes use of a smartphone's camera. Even if we assume a relaxed estimate of the camera field view, (somewhere between 60 to 70 degrees), the application would still need to transfer data at the rate of 10 Gb per second!!

Well, in practice an uncompressed 60 FPS, 12 bits/pixel video of 4k resolution can be transmitted at 20–30 Mb/s when compressed with lossy algorithms [4]. But that is still very high when compared to the average upload speed offered by the cellular providers in the US (9.75 Mb/s) [5].

A Data War is Imminent

The global AR/VR data traffic [3] is expected to grow 12-fold from 22 petabytes per month in 2017, to 254 petabytes per month in 2022.

As the AR industry consolidates its position, it is going to want that the download-heavy bandwidth allocation is done away with. The streaming platforms, on the other hand, will continue to stand their ground and maintain the speed asymmetry that clearly is to their advantage.

Eventually, it will come down to the end-user. This battle will be settled only when the average Joe and Jane decide whether they want to “Netflix” or “Pokemon Go”. For now, we just wait and watch and let it play out. Pun intended.

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Event Report

11th ISAJ Annual Symposium-2020 (Web)

Conveners: Dr. Swapnil Ghodke, Nagoya University
Dr. Bhupendra Sharma, Ritsumeinkan Uni.
Dr. Mahendra Kumar Pal, NIED

The 11th annual ISAJ Symposium "Innovations in Science and Technology for New Issues and Challenges" was held virtually on December 4th, 2020, using Zoom platform. Symposium was also live streamed on YouTube.

In the welcome address, Dr. Sunil Kaul, Chairman, introduced the ISAJ and its evolution. H.E. Mr. Sanjay Kumar Verma, Ambassador of India to Japan, delivered a pre-recorded inaugural address. The Ambassador outlined current state of India-Japan collaboration in the fields of S&T, with a strong message to further enhance the start-up ecosystem striving to find innovative solutions to the new issues and challenges of the society of the two countries. He further informed about a new area of cooperation in the field of ICT, as India being powerhouse of software and Japan of hardware, it is a good fit between two countries and will take the S&T collaboration to a new horizon.

Prof. Masaru Hori, Director, Center for Low-temperature Plasma Sciences (cLPS), Nagoya University delivered a keynote lecture on overview of plasma sciences, its role in medicine and agriculture, and the outlook for future plasma processes towards SDGs.

In a special address, Dr. Usha Dixit, Counselor S&T, Embassy of India, Tokyo, highlighted various key S&T initiatives and missions of the Indian government - Digital India, Science and Tech of Yoga and Meditation (SATYAM), National Supercomputing Mission (MeitY), Clean Coal Technologies and Quantum Science and Technology Mission, to name a few. She also outlined the ongoing funding schemes and opportunities of the government of India, targeting the Indian diaspora. Prof. B.S. Murty, Director, IIT Hyderabad, in his special address, talked on synergistic growth through collaboration between India and Japan.The inaugural session was closed with a vote of thanks from Dr. Alok Singh, Vice-Chairman of ISAJ.

A special interest session on "COVID-19 Pandemic" was organized, which had talks on immunological mechanism, genetics of SARS-CoV-2, role of Ashwaganda in human health, psychological effect on mental health and rise of AI in societal transformation amid pandemic.

Plenary talks, Invited talks and Young researcher sessions were organized into three parallel sessions, namely, 1. Industrial and Technological Innovations, 2. Human Health and Safety and 3. Energy and Environment. Organization into parallel sessions was adopted for the first time in an ISAJ Annual Symposium. The symposium had 8 plenary talks, 26 invited talks and 24 student oral presentations.

Organizing the 11th ISAJ annual symposium virtually was a special opportunity as it allowed us to reach to a broader audience countrywide in Japan and to have participants from beyond Japan. Symposium was attended by more than 100 participants majoring in a broad spectrum of science and technology. Participants included 10 prominent academicians, 10 established research scholars, 30 young researchers, and 24 students representing academia, industry, and national laboratories. The symposium was organized by organizing committee of 16 young researchers under the guidance of the executive committee of the ISAJ.

Symposium concluded with the presentation of awards. Dr. Kedarnath Mahaptra presented six best presentation awards to 1) Mr. Ashish Kaul (AIST, Tsukuba) and 2) Mr. Ahmed Elwakeel (AIST, Tsukuba) for session on "Human Health and Safety", 3) Mr. Hitesh Supe (Hokkaido University) and 4) Ms. Manpreet Kaur (NIMS, Tsukuba) for session on "Energy and Environment", and 5) Mr. Hannibal Paul (Ritsumeikan University) and 6) Mr. Raghav Soni (Osaka University) for session on "Industrial and Technological Innovations".

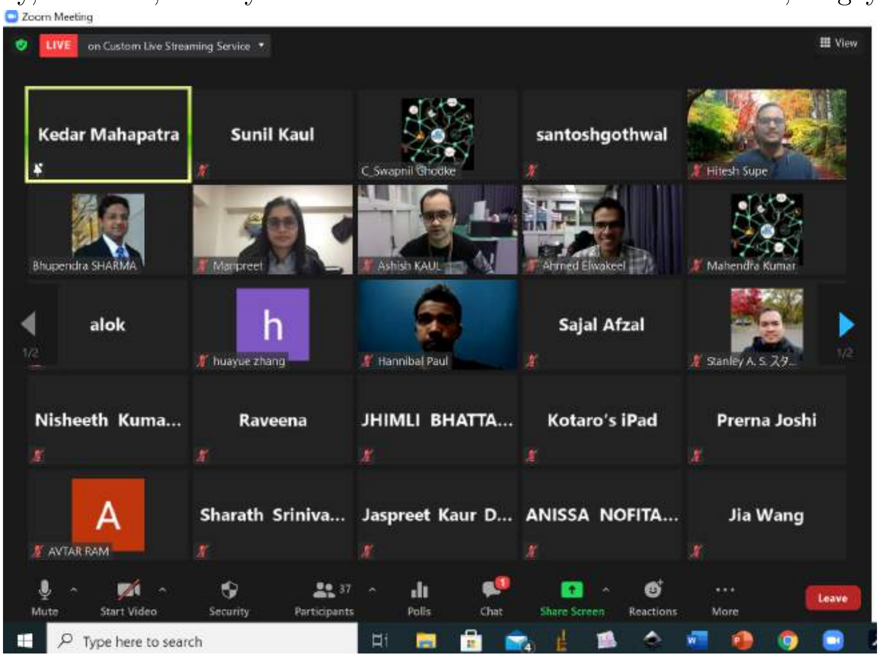
11th ISAJ Annual Symposium-2020 (Web)

Inaugural Address

Dr. Usha Dixit, Counsellor S&T

Prof. B.S. Murty, Director, IIT Hyderabad

Prof. Masaru Hori, Nagoya University



Participants and Best presentation awardee

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About ISAJ

The Indian Scientists' Association in Japan (ISAJ) is a Non-Profit Organization (NPO) aimed at networking and promoting Science and Technology Cooperation between India and Japan.

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