C-/X-/Ku-band transmission/reception GaN MMIC chipset technology

GaN MMIC chipset technology for C-/X-/Ku-band Transceiver

Patent title	Method for producing nitride-based semiconductor device	**Inventor**	Electronics and Telecommunications Research Institute / Jung Hyun-wook and seven more
Patent application No.	KR 10-2020-0770294 (in a filing process)	**Authority status**	Filed

Technicality

Technology overview

The technology is a technology related to a method for producing a gallium nitride-based semiconductor element, by which the frequency characteristics of the element are improved. The technology is a technology related to a method for producing a nitride-based semiconductor element capable of being operated at a high frequency by recessing and etching a part of a protective film to form an air gap layer so as to reduce extrinsic delay components generated in a gallium nitride HEMT, and by reducing a fringing capacitance generated between a gate electrode and a two-dimensional electron gas layer is reduced.

Development background and problem to be solved

- With the development of modern wireless communication technologies and the expansion of the mobile communication market, it is required to develop a technology for a gallium nitride-based high electron mobility transistor (HEMT) capable of performing high-speed processing of signals in a GHz band or higher.
- In order to develop a gallium nitride-based HEMT operated in a higher frequency band, a process technology for reducing an extrinsic delay component generated in a gallium nitride-based HEMT is required.

Excellence and discrimination of technology

▶ Excellence of technology

- The output of one MMIC is three times or more the output power characteristics of GaN 30 W or more compared to GaAs 10 W.
- It is possible to upgrade a system with excellent efficiency characteristics with 40% of GaN compared to about 30% of GaAs.
- Excellent heat dissipation is achieved due to the high channel temperature characteristics of GaN 250°C compared to GaAs 150°C and the excellent thermal conductivity of an SiC substrate.

▶ Discrimination of technology

- A GaN high power amplifier MMIC has higher output power and higher efficiency than an existing 10 W class GaAs high power amplifier MMIC.
- The technology contributes to the epochal development of a power amplification technology by achieving excellent heat dissipation with high channel temperature characteristics and excellent heat conduction characteristics.
- Currently, core transceiver components such as an X-band high-power amplifier MMIC are designated as export-restricted items and cannot be imported into Korea. Technology independence can be ensured through corresponding technology development.

C-/X-/Ku-band transmission/reception GaN MMIC chipset technology

GaN MMIC chipset technology for C-/X-/Ku-band Transceiver

Implementation method

According to the present invention,

- A part of a protection film between buffer layers is removed, and the protection film is etched to form a wide recess width.
- When a gate electrode is formed at the wide recess width, air gap layers are formed at both sides of the lower end of the gate electrode.
- The air gap layer can provide a semiconductor element with improved frequency characteristics by reducing a fringing capacitance generated between the lower end of a gate electrode and a two-dimensional electron gas layer due to a low dielectric constant.

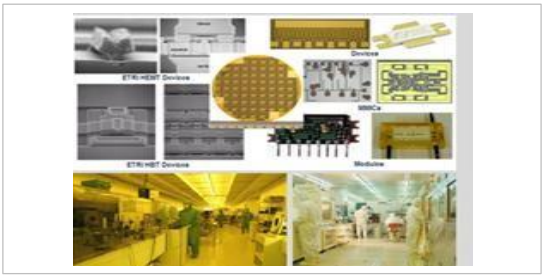


Figure 1 GaN HEMT element design process

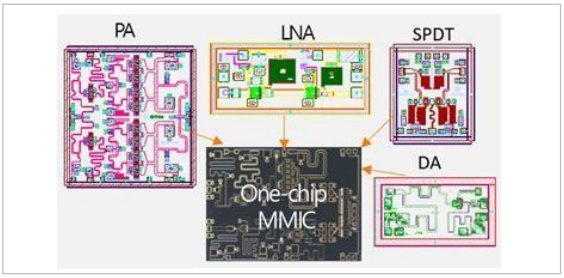


Figure 2 One-chip MMIC

Degree of technology completion (TRL)

Degree of technology completion: TRL4 (Lab Scale prototype development stage)

TRL1	TRL2	TRL3	TRL4	TRL5	TRL6	TRL7	TRL8	TRL9
Technical principle presentation	Technology concept setting	Technology concept verification	Lab Scale prototype development	Implementation environment application experiment	Full Scale prototype development	Quasi-commercial product development	Commercial product development	Commercial product implementation

Utilization

Utilization field and applied product

Utilization field

· Various communication fields including high-power radars and the like
(AESA radars, vessel radars, ship radars, etc.)
· Satellite communication terminal
· Base station amplifier

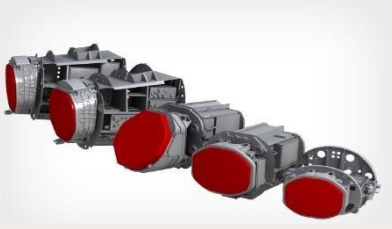


Figure 1 AESA radar

Applied product

· Power amplifier for a base station
· Transceiver/transistor module for a radar

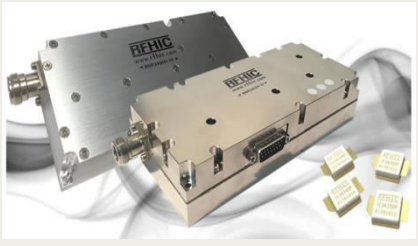


Figure 2 GaN power amplifier

C-/X-/Ku-band transmission/reception GaN MMIC chipset technology

GaN MMIC chipset technology for C-/X-/Ku-band Transceiver

Technology trend

- Currently, gallium nitride (GaN) is widely used in our daily life as a core material for smartphones, displays, electronic products, and high-frequency devices. Since a signal conversion speed is fast, and an energy loss rate is low in this process, the range of the application thereof is rapidly expanding to high-frequency high-power communication systems, automotive power systems, and semiconductors for extreme environments.
- Advanced countries such as the US, Japan, and Europe are developing high-speed, low-loss, and high-efficiency GaN power semiconductors through government-led projects. RFHIC developed a GaN transistor amplifier for the first time in Korea, and is currently developing a high-efficiency GaN MMIC with an average output of the XW class for products of 6 GHz or less. In addition, Samsung Electronics developed a 2 GHz band 20 W GaN amplifier for base stations/repeaters by using Cree's commercial GaN HEMT.

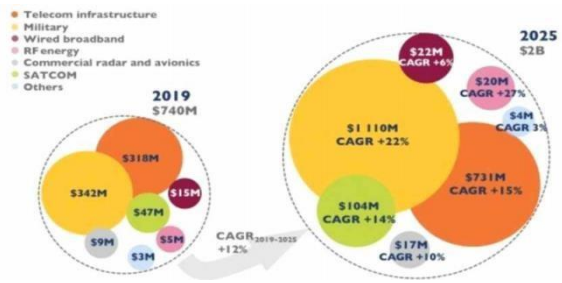
Family patent status

Application nation	Application No. (Application date) / Registration No.	Title of the invention
KOR	10-2020-0099525 (in a filing process)	Method for composing electric circuit of semiconductor channel resistor
KOR	10-2020-0099524 (in a filing process)	SPDT switch using inductor at gate stage for improving power transfer capability
KOR	10-2020-0091906 (in a filing process)	High electron mobility transistor and production method thereof

Market prospect

Target market size and prospect

- The global GaN semiconductor-based RF device market was approximately USD 740 million as of 2019, has grown at an average annual rate of about 12% since 2019 when taking into account the introduction of 5G mobile communication methods, market environments, and industry conditions, and is expected to reach USD 20 million by 2025.
- There was the Chinese government's large-scale investment recently, and commercialization of 5G in major advanced countries is imminent. Thus, investment in the communication infrastructure is increasing. In military applications, the overall market is expected to increase as existing systems are replaced with GaN-applied RF components to improve national security.



Graph **World GaN RF device market**

<Data: Yole Development(2020)>

Figure **Gallium nitride epiwafer production equipment**

<Data: Ivworks Co., Ltd.>

Technology transfer query

DH 두호특허법인 / ㈜두호기술경영 DooHo IP Law Firm / DooHo Tech. & Mgt. Inc.

Person in charge KyuhyeongLIM

Contact 070-4333-8021

Email khlim@doohopat.co.kr

Technology transfer process

Explore promising technologies → Contract consultation → Apply for technology transfer → Negotiate and sign contracts → Follow-up support