Normally Off MCT technology of 1600V or higher

Technology of Normally Off MCT (MOS Controlled Thyristor) rated above 1600V

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Patent title MCT device and method for producing same

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Authority status Unpublished

Technicality

Technology overview

The technology is a thyristor series power semiconductor technology which can be turned on/off with a MOS gate. The technology is a silicon semiconductor high voltage switch (MCT, MOS controlled thyristor) technology of 1600 V or higher, in which a voltage loss is low at higher current density compared to power semiconductors such as MOSFETs and IGBTs and a large peak current and high di/dt characteristics are secured in the pulse power application field which is the main application field of MCT.

Development background and problem to be solved

- Key components in the military field are being supplied exclusively by Silicon Power Corp. of the United States, so supply is limited. Thus, components need to be localized.
- After commercialization of MCT, when applied to the civil field, a power loss is small. By using a voltage driving method by an MOS gate, the configuration of a driving circuit is easy, and high-power components and power supply systems with rapid switching speeds can be achieved. In particular, with high peak currents and di/dt characteristics, the technology can be applied to various pulse power systems.

Excellence and discrimination of technology

▶ Excellence of technology

- The technology is a thyristor series power semiconductor device having a low voltage loss in an on-state.
- 1600 V and 2500 V class normally-off MCT which can not only control turn-on and turn-off by integrating MOS gates but also enable turn-off from 0 V is achieved.
- As a core component of a missile fuse detonator, the technology is superior to an existing spark gap switch in terms of accuracy, durability, stability, price, and implementation of a driving circuit.
- With high peak currents and di/dt characteristics, the technology can be applied to various pulse power applications such as laser devices and plasma devices.
- The efficiency of various power components can be improved in the high power field, and the effects of improving component performance and saving energy are ensured.

▶ Discrimination of technology

- An MCT technology for high voltage power can be the basis for the development of power semiconductors of various voltage/current levels such as IGBT and Power MOSFET, and can be used not only in the defense field but also for power semiconductor components such as industrial equipment and electric vehicles.
- An MOS driven thyristor can perform low gate voltage (< 5V) turn-on (adjustable) and 0 V turn-off.
- The technology simultaneously has the advantages which are a low voltage loss of a thyristor, MOS gate driving of IGBT, and rapid switching speeds.
- A high pulse current and di/dt, small turn-on jitter characteristics enable replacement of thyratrons and spark gaps for pulsed power switches.

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Implementation method

According to the present invention,

- A thyristor power semiconductor can perform turn-on and turn-off by voltage driving by an MOS gate.
- A low normal voltage loss is exhibited with large peak current and high pulse current (2.5>kA) and di/dt (>35kA/μs) values during an On operation.
- MCT in which a turn-on gate voltage can be adjusted and turning-off at 0 V is possible is achieved.

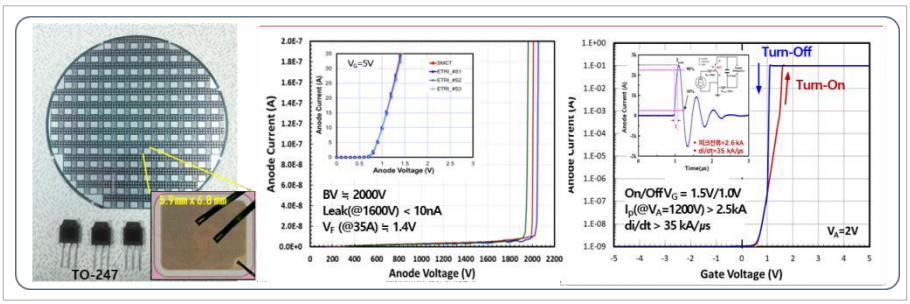

Figure 1 1600 V class MOS controlled thyristor (MCT) performance (example)

Degree of technology completion (TRL)

Degree of technology completion: TRL5 (implementation environment application experiment)

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

- Pulse power system (plasma, laser system, or the like)
- Electric vehicle and battery
- Renewable/alternative energy
- UPS and motor drives
- Power components for industrial equipment

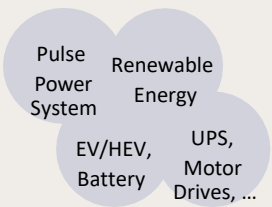

Figure 1 Power conversion/transmission system

Applied product

- Missile fuse
- Electromagnetic launching device
- High energy detonation device
- Replacement of spark gaps and cyratron

Figure 2 Missile fuse ESAD

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Technology trend

- After being announced by the General Electric R&D Center (V.A.K. Temple) in 1988, MCT was actively researched in the United States, Japan, and Europe in the 1990s and early 2000s.
- Currently, 1400 V class MCT (SMCT) (an EL item) is produced or sold only by US Silicon Power Corp. (which acquired the Excelitas' solidtron field in 2020).
- Recently, a number of documents have been published for the application of a pulse power system such as an EUV source, an ozonizer, and a detonator mainly in China USTC and the like.
- ETRI developed 1400 V class MCT in 2017 to secure MCT products with characteristics equivalent to those of SMCT (in a system application test and evaluation process), and is developing 1400 V class normally-off MCT and 1700 V and 2500 V class MCT in 2020.

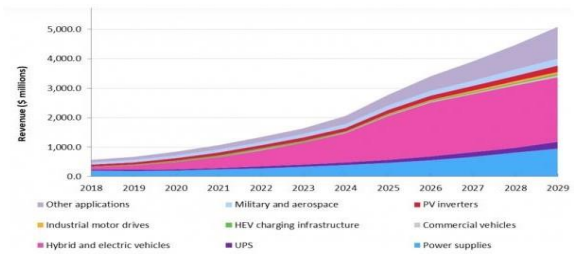
Family patent status

Application nation	Application No. (Application date) / Registration No.	Title of the invention
KOR	KR 10-2020-0077396 (in a filing process)	Semiconductor device and production method thereof

Market prospect

Target market size and prospect

- The size of the global power semiconductor market is expected to reach USD 600 million in 2018, and will reach USD 1 billion (about KRW 1.2 trillion) in 2021. The market size is expected to continue to rise sharply to USD 5 billion in 2029. The demand for high voltage resistant power energy semiconductors with voltage resistance of over 1,700 V is on the rise in order to achieve high-capacity and high-efficiency systems.
- The thyristor market for electric power is a market of USD 800 million in 2017 and is maintaining a CAGR of over 1%. The market occupies an independent area for large-scale applications such as defense and aerospace, and the MCT market is expected to expand.



Graph **Power semiconductor market size**
<Data: Omdia >

Picture **ETRI silicon semiconductor laboratory**
<Data: ETRI>

Technology transfer query

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Technology transfer process