The 1st Global COE International Symposium
Satellite meeting “Recent activities of IDER units”

Research Unit of the Concept for Next Generation Power Semiconductor Devices

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- Summary
Power Electronics engineering is one of the promising solutions for problems of energy saving and CO₂ reduction.

- Motor drives
- Power systems
- Distributed generations

High efficiency, High performance
Why next generation devices?

- Higher efficiency, lower volume
  → Higher power density

G. Majumdar, “Power Modules As Key Component Group For Power Electronics,” the Proceedings of PCC 2007, Nagoya. (c) 2007 IEEE
Advantages of wide band gap devices

- Higher voltage
- Higher frequency \( \Rightarrow \) smaller \( L \) and \( C \)
- Higher operating temperature
- Lower losses \( \Rightarrow \) smaller cooling components
  - Conducting losses
  - Switching losses

Higher power density

<table>
<thead>
<tr>
<th></th>
<th>Bandgap (eV)</th>
<th>Breakdown strength (MV/cm)</th>
<th>Electron mobility (cm(^2)/Vs)</th>
<th>Electron saturation velocity ((x10^7\text{cm/s}))</th>
<th>Thermal conductivity (W/cm deg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GaN</td>
<td>3.43</td>
<td>3.0</td>
<td>1200</td>
<td>2.7</td>
<td>1.3</td>
</tr>
<tr>
<td>SiC</td>
<td>3.26</td>
<td>2.8</td>
<td>1000</td>
<td>2</td>
<td>4.9</td>
</tr>
<tr>
<td>Si</td>
<td>1.12</td>
<td>0.3</td>
<td>1350</td>
<td>1</td>
<td>1.51</td>
</tr>
</tbody>
</table>
Goal of our IDER unit

- Establishment of the concept of GaN devices for power electronics applications
  - Driving force for development and application of GaN devices
    - “Application-driven” development
<table>
<thead>
<tr>
<th>Name</th>
<th>Specialty area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yushi Miura</td>
<td>Power Electronics (PE) Engineering, Unit Leader</td>
</tr>
<tr>
<td>Mamoru Imade</td>
<td>GaN crystallization</td>
</tr>
<tr>
<td>Hiroaki Kakigano</td>
<td>PE Engineering, Distributed Generations</td>
</tr>
<tr>
<td>Yoshinari Kamakura</td>
<td>Device simulation</td>
</tr>
<tr>
<td>Fumio Kawamura</td>
<td>GaN crystallization</td>
</tr>
<tr>
<td>Osamu Saeki</td>
<td>Optimization Analysis</td>
</tr>
<tr>
<td>Hideharu Sugihara</td>
<td>Optimization Analysis</td>
</tr>
<tr>
<td>Rejeki Simanjorang</td>
<td>PE Engineering, Switching power supplies</td>
</tr>
<tr>
<td>Toshifumi Ise</td>
<td>PE Engineering, Unit Advisor</td>
</tr>
<tr>
<td>Hideo Iwamoto</td>
<td>Power Device Application, Unit Advisor</td>
</tr>
</tbody>
</table>
Targets in the first phase (~2008)

1. Market research and Evaluation of required performance of next generation devices
   ➡️ edback to crystallization engineering

2. Literature research and construction knowledge database

3. Prediction of device performances and development of device design methodology
   ➡️ device simulation and optimization technique

4. Establishment of implementation technology
 Targets in the second phase (2009~)

1. Device simulation of the GaN devices optimally-designed by the developed methodology
2. Preparation of GaN crystal for power devices

Our final targets are...

- Fabrication of the optimally-designed GaN power device,
- Evaluation of performance of the circuits employing the GaN power devices.
Present activities

- Literature research and construction of the knowledge base on the Web.
- Evaluation of performance of the next generation power devices at present.
  - Dynamic performance of passive circuit components such as inductors, capacitors, and resistors will be also investigated.
For Knowledge management, knowledge base has been constructed on the Web using Blog technology.

- Literature information
- Technical intelligence
- Seminar and lecture information
- Activity reports
Present activities

- Literature research and construction of the knowledge base on the Web.
- Evaluation of performance of the next generation power devices at present.
  - Dynamic performance of passive circuit components such as inductors, capacitors, and resistors will be also investigated.
Evaluation of performance of the next generation power devices

Measurement of Dynamic characteristics
- Measurement and evaluation of performance
- Loss estimation
- Modeling of switch devices and passive components
Summary

- To establish the concept for application of the GaN power devices, our IDER unit has been organized by the experts in different engineering fields.

- The device simulation method, the device design methodology and the circuit implementation technology, which will be interdisciplinary developed in this unit, will be novel tools for development and application of the power devices.