OpECS

Optical probe Electric Current Sensor

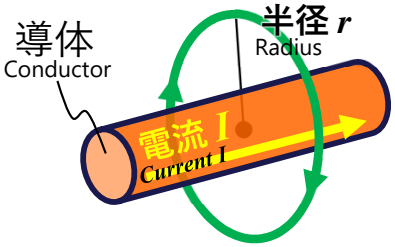
CITIZEN FINEDEVICE CO., LTD.

Marubeni Ele-Next

OpECSの動作原理
Operating principle of OpECS

アンペールの法則
Ampere's circuital law

$$H = \frac{I}{2\pi r}$$



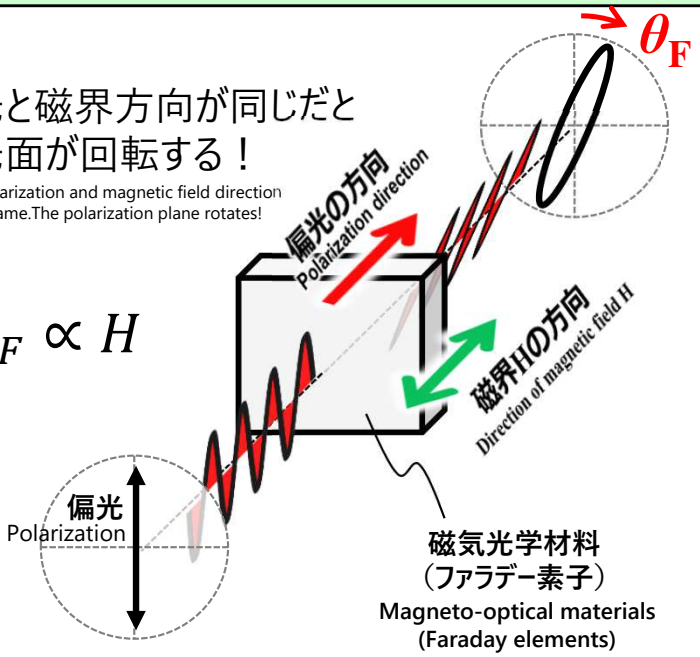
磁界 H
Magnetic field

電流が流れると磁界が発生する！
When a current flows, a magnetic field is generated!

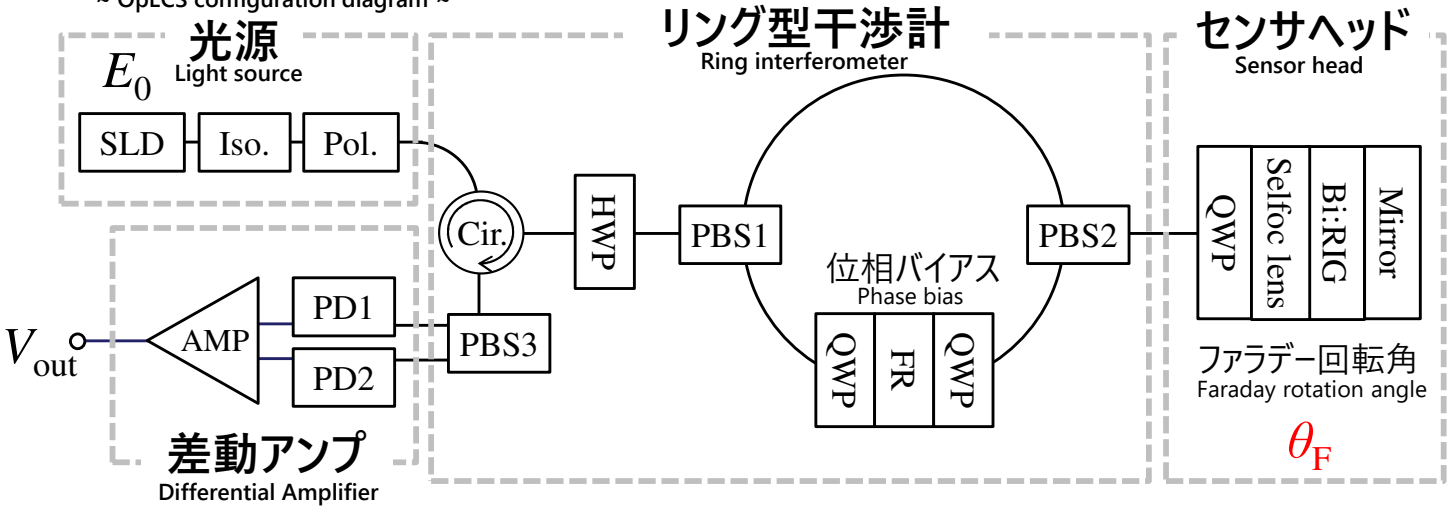
ファラデー効果
Faraday effect

偏光と磁界方向が同じだと
偏光面が回転する！
When polarization and magnetic field direction are the same.The polarization plane rotates!

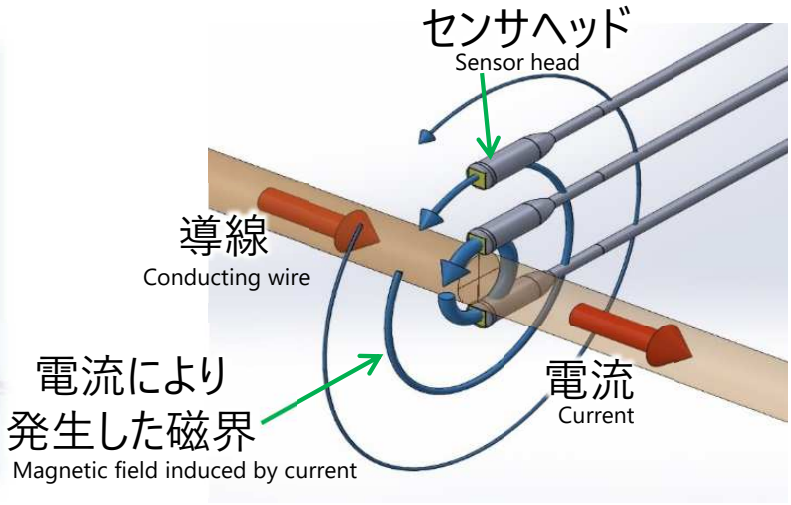
$\theta_F \propto H$



～ OpECSの構成図 ～
~ OpECS configuration diagram ~



$V_{out} \propto {E_0}^2 \cos(4\theta_F - \pi/2)$ ※OpECSは電流磁界によるファラデー回転角を検出します
OpECS detects Faraday rotation angle by current magnetic field

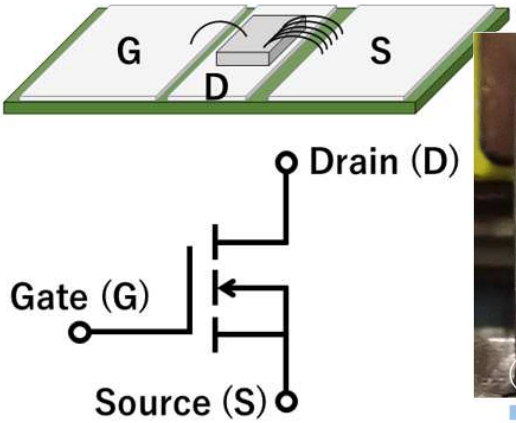


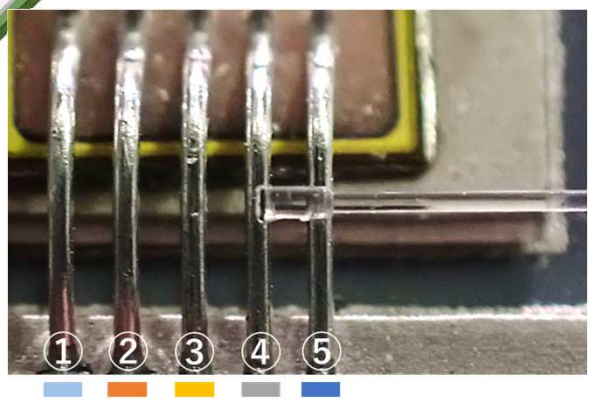
OpECSの測定事例
OpECS measurement examples

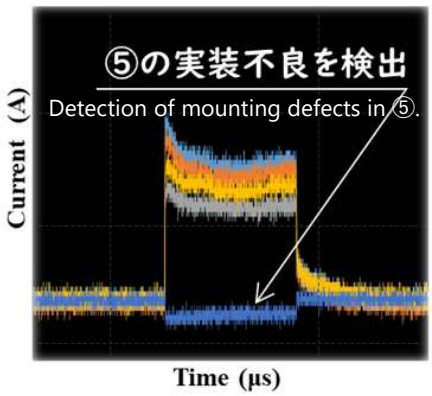
Bonding Wireの測定
Measurement of Bonding wire

Source ⇄ Drain をつなぐ５本の **Φ300μmワイヤに流れる電流** 波形！

Current waveforms in 5 Φ300μm wires connecting source-drain



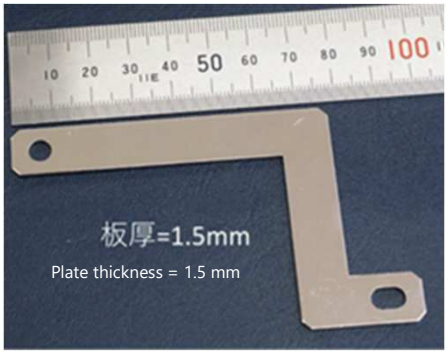


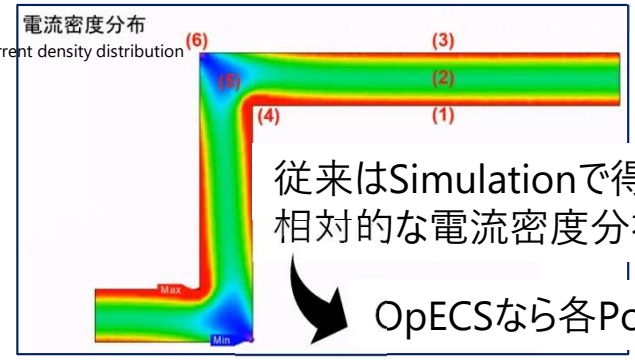


バスバーの測定
Busbar measurement

Conventionally, only relative current density distribution could be obtained by the contour diagram obtained by Simulation.only relative current density distribution was known.

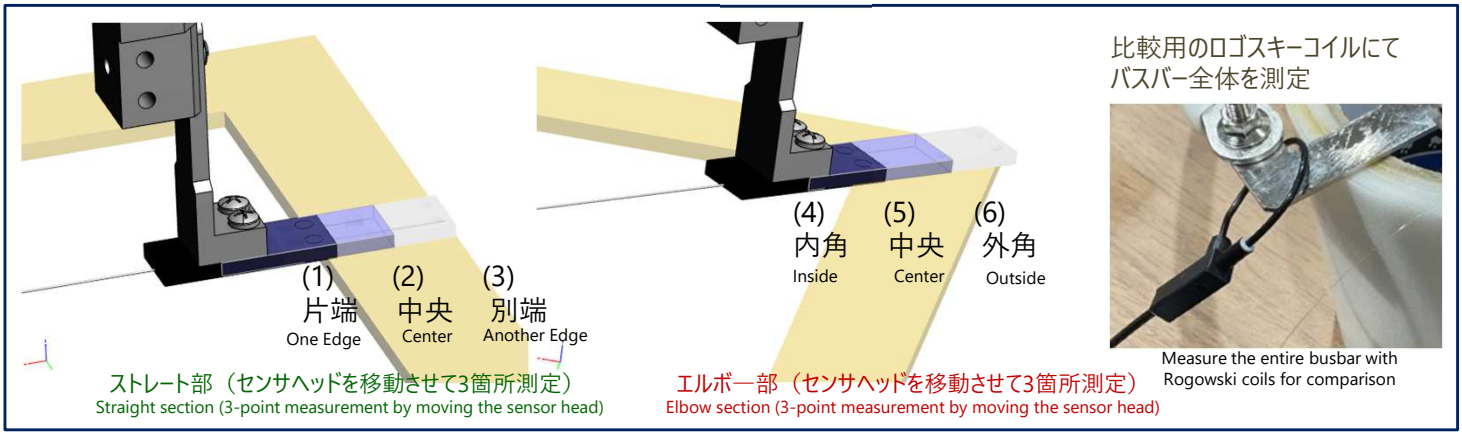
OpECS can see waveforms at each point





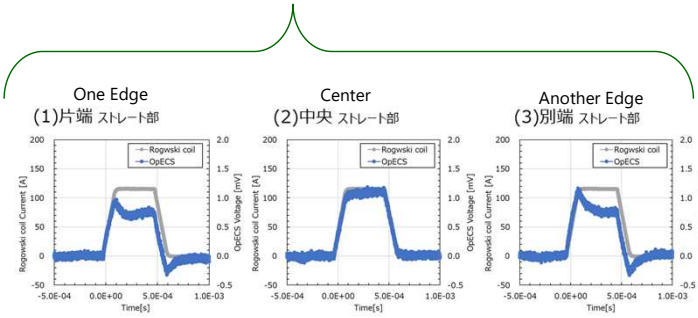
従来はSimulationで得られるコンター図により
相対的な電流密度分布しか分からなかった

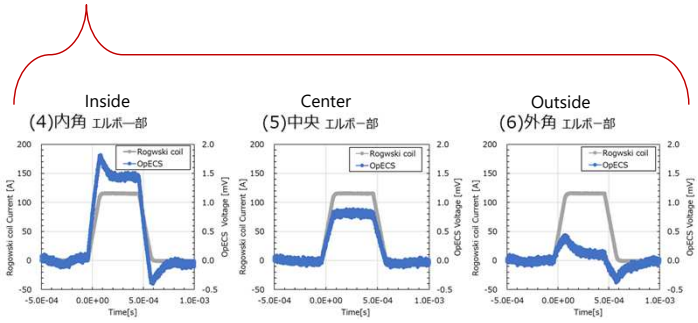
→ OpECSなら各Pointの波形が見える



比較用のロゴスキーコイルにて
バスバー全体を測定

Measure the entire busbar with
Rogowski coils for comparison

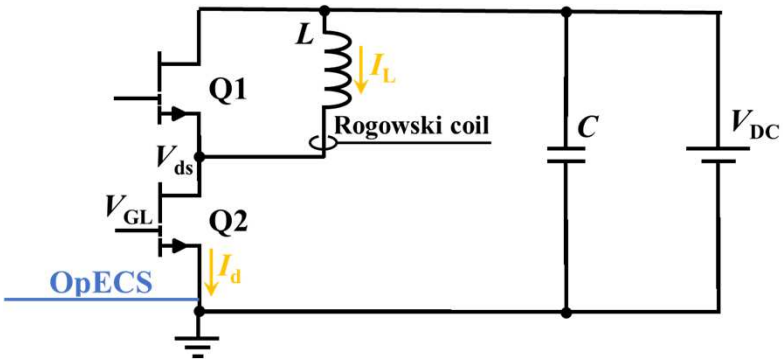




OpECSによるGaNスイッチング損失の測定
Measurement of GaN switching loss by OpECS

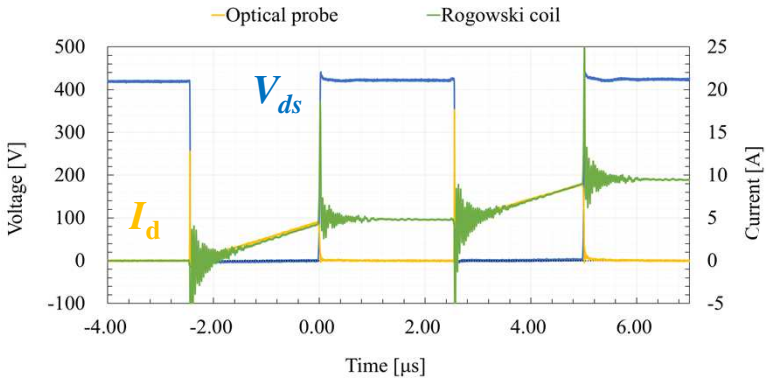
GaN HEMT (GS66508B, 650V, 30A : GaN systems)が2つ実装されたハーフブリッジ評価基板 (GaN systems; GS66508B-EVBDB1)でダブルパルス試験を実施した

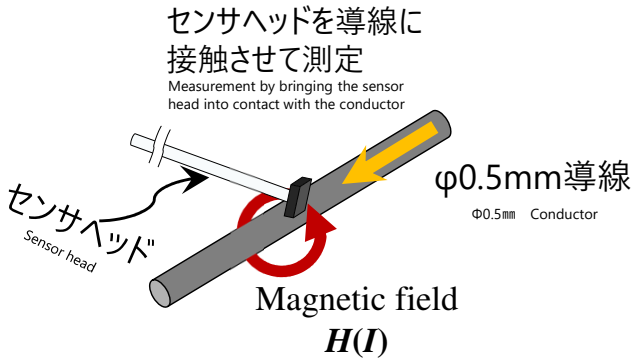
Double-pulse test was performed on a half-bridge evaluation board (GaN systems; GS66508B-EVBDB1) with two GaN HEMTs (GS665008B, 650V, 30A: GaN systems) mounted.



ロゴスキーコイル と光プローブ電流センサで同時計測し、光プローブ電流センサの**振幅**を校正した

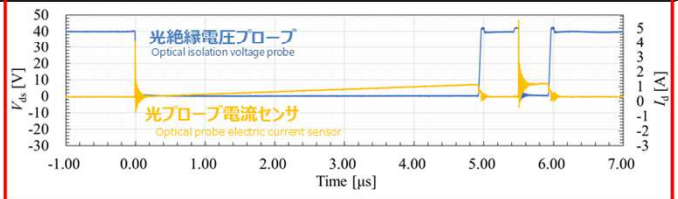
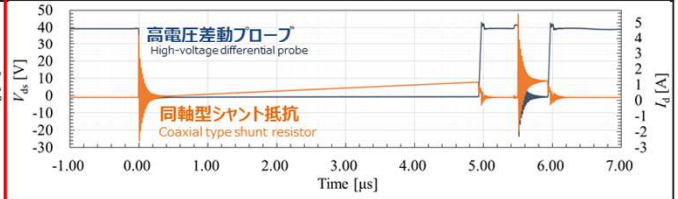
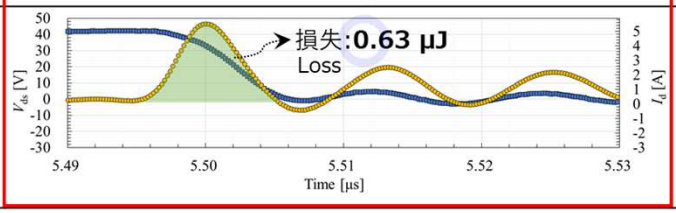
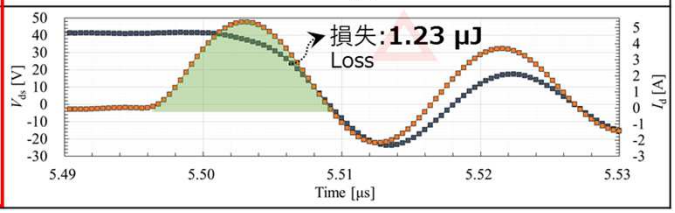
Simultaneous measurements were made with the Rogowski coil and the optical probe current sensor, and the amplitude of the optical probe current sensor was calibrated to match the output of the Rogowski coil.





光絶縁計測との比較のため、高電圧差動プローブと同軸型シャントでも同様の条件で測定を実施

For comparison with optical isolation measurements, measurements were made under similar conditions with a high-voltage differential prope and a coaxial-type shunt

電圧センサ Voltage sensor / 電流センサ Current sensor	光絶縁電圧プローブ (PMK; FF-1500) Optical isolation voltage probe / 光プローブ電流センサ Optical probe electric current sensor	高電圧差動プローブ (PMK; BumbleBee) High-voltage differential probe / 同軸型シャント (T&M RESEARCH PRODUCTS; SDN-10) Coaxial type shunt resistor
測定セットアップ Measurement Setup		
ダブルパルス波形 Double pulse waveform		
ターン・オン損失 Turn-on Loss		

光絶縁計測(OpECS)は低侵襲でターン・オン損失を測定できる

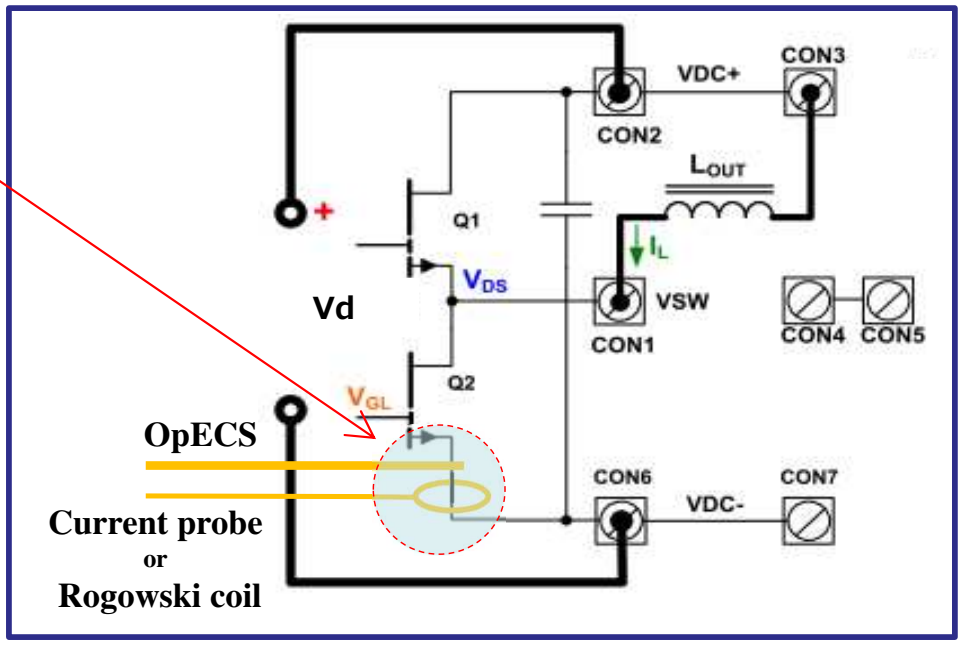
Optical isolation measurement (OpECS) can measure turn-on losses without affecting the circuit

GaN測定による各電流プローブとの比較
Comparison with each current probe by GaN measurement

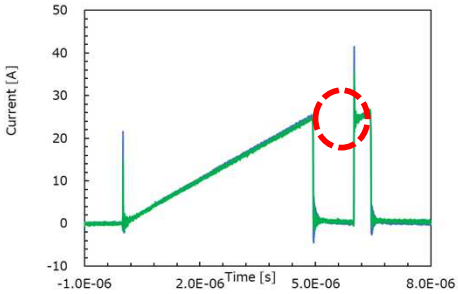
回路のこの部分の
電流波形を取得

Get the current waveform of this part

GaN HEMTを駆動させるダブルパルス試験回路図
Double-pulse test circuit diagram for driving GaN HEMT

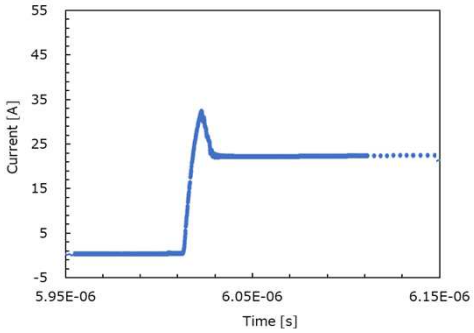


取得電流波形全体
Overall diagram of current waveform

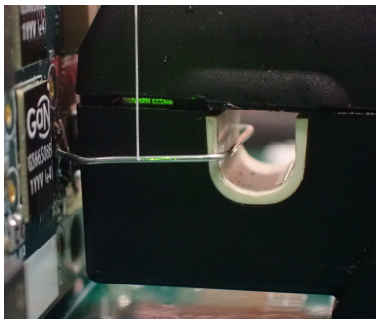
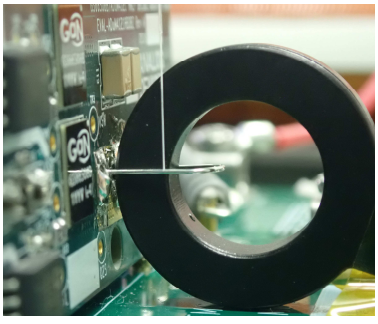
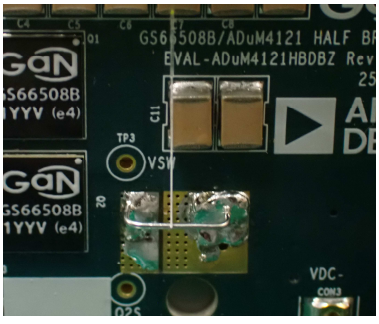
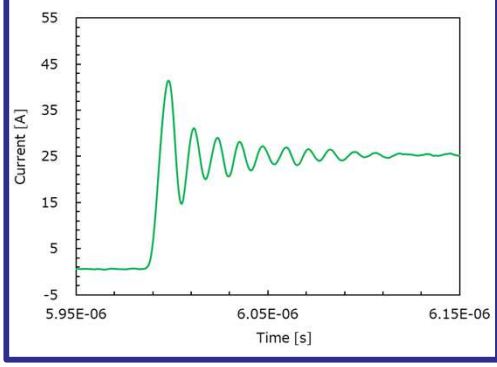
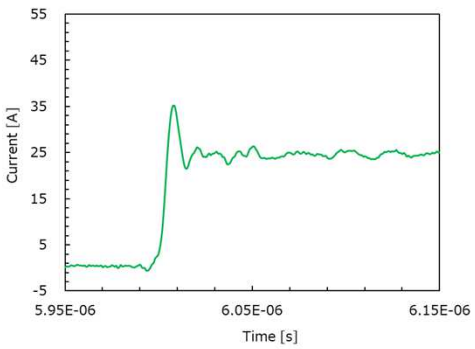
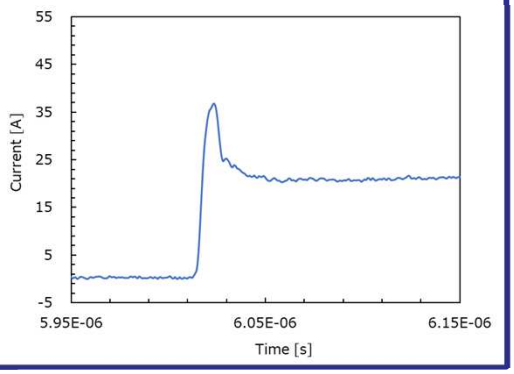


シミュレーションから算出した
真の波形

True waveform calculated from simulation



部拡大波形比較
Table comparing expanded waveforms

Current probe	Rogowski	OpECS
		
		

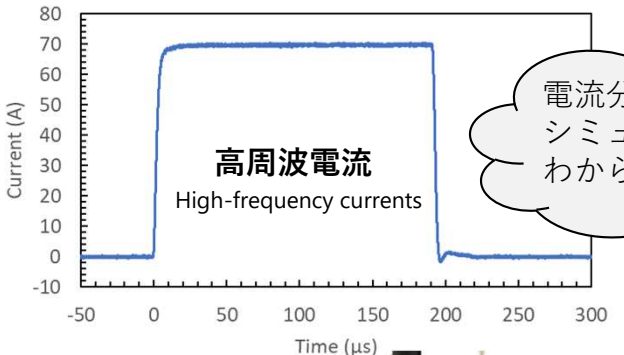
OpECSは真の波形取得が可能
OpECS can obtain true waveforms

バスバー・平面配線の電流分布計測

Current distribution measurement of busbars and flat wiring

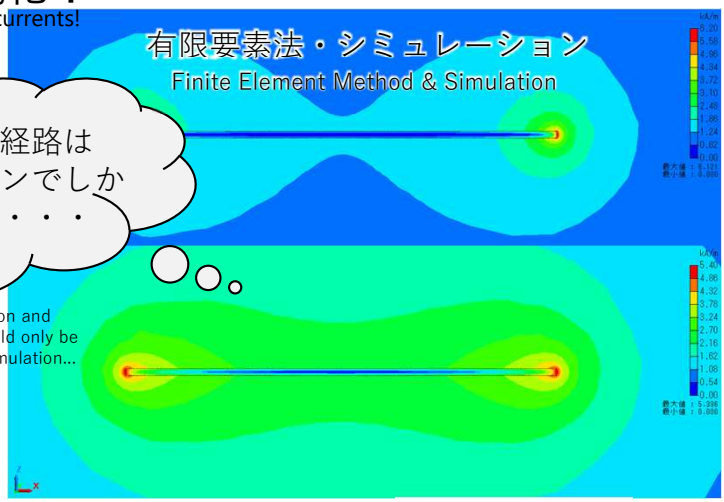
高周波電流で生じる表皮効果を実測・可視化！

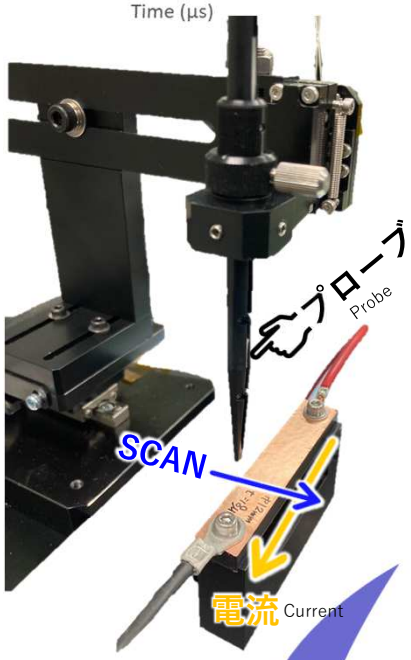
Measurement and visualization of skin effect produced by high-frequency currents!

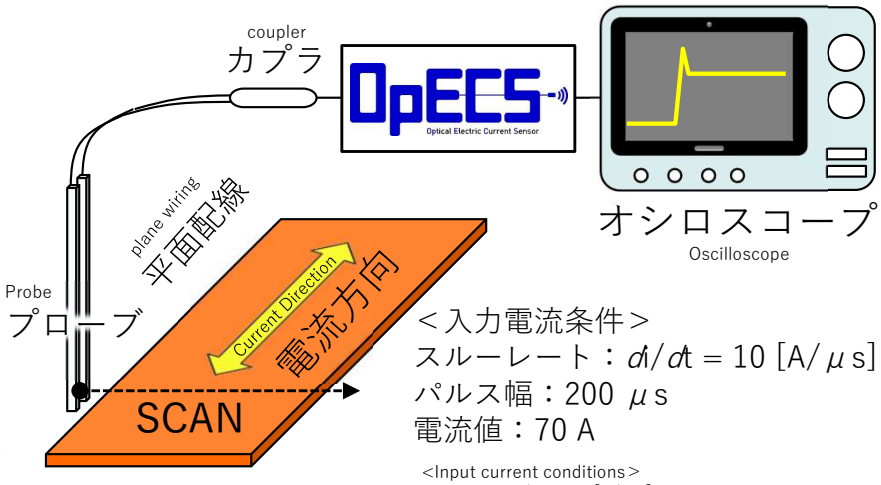


電流分布や電流経路はシミュレーションでしかわからなかった・・・

Current distribution and current paths could only be determined by simulation...

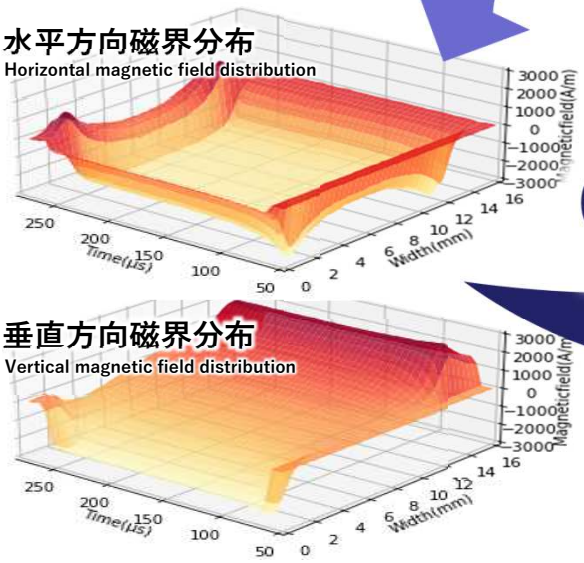






＜入力電流条件＞
スルーレート：$di/dt = 10$ [A/μs]
パルス幅：200 μs
電流値：70 A

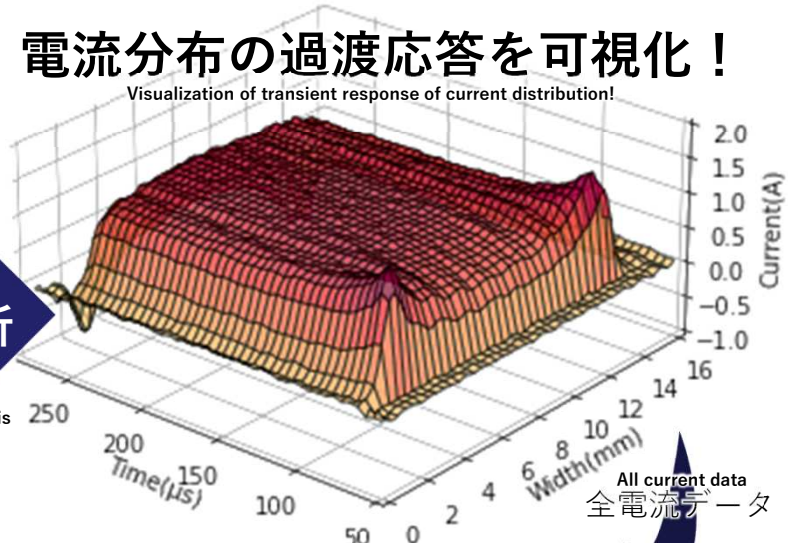
<Input current conditions>
Slew rate: di/dt = 10 [A/μs]
Pulse width: 200 μs
Current value: 70 A



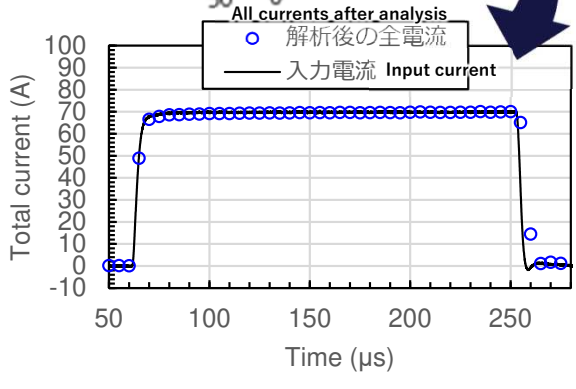
逆解析
Inverse analysis

電流分布の過渡応答を可視化！

Visualization of transient response of current distribution!



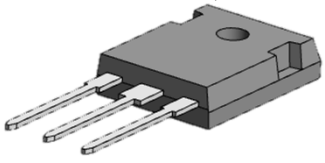
All current data
全電流データ



＜本技術の応用先＞

- ◆ ラミネートバスバーの電流解析
- ◆ 積層基板の電流測定
- ◆ デバイスの複数のリードを一括測定

<Applications of this technology>
◆Current analysis of laminated bus bars
◆Current measurement of laminated circuit boards
◆Batch measurement of multiple leads of a device

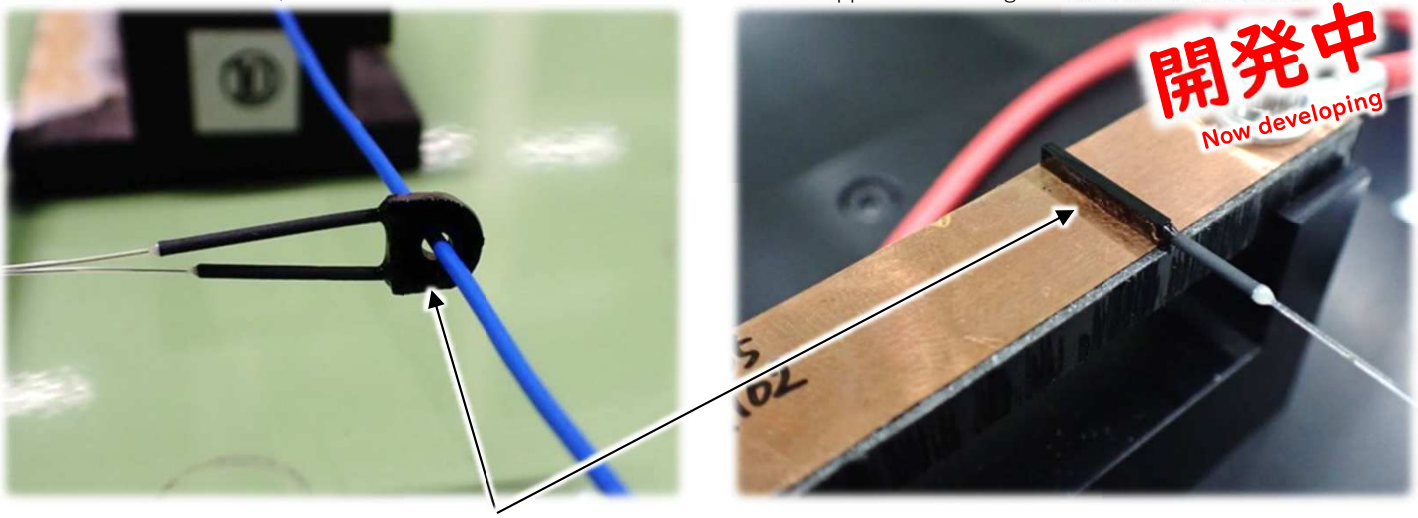


全電流測定
Total current measurement

小型センサヘッドで様々な導体形状に対応！
Compact sensor head supports various conductor shapes!

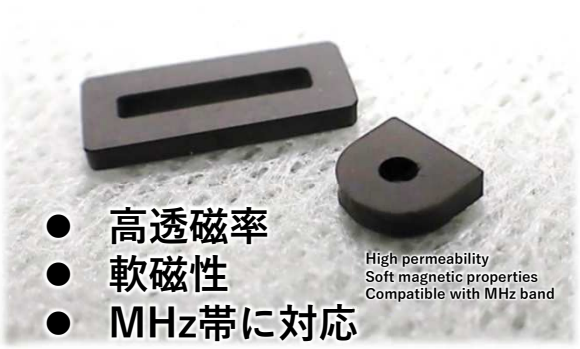
クローズドループ型
Closed loop type
電線・ケーブル・ワイヤーに対応
For wires, cables and wires

オープンループ型
Open Loop Type
バスバー・PCB基板の平面配線に対応
Supports flat wiring of busbars and PCB boards



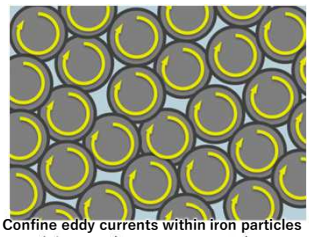
集磁ヨーク Magnetic collecting yoke
||
高周波まで対応可能な
メタルコンポジット材料を採用
The material is a metal composite that can handle high frequencies

信州大学と共同研究
Joint research with Shinshu University

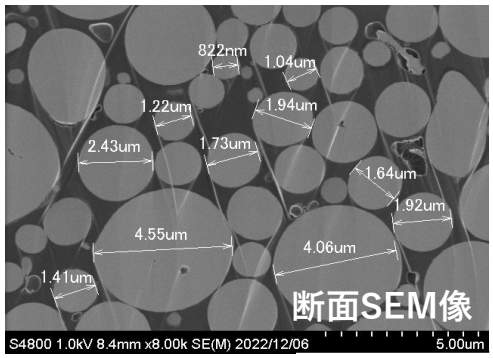


- 高透磁率
- 軟磁性
- MHz帯に対応

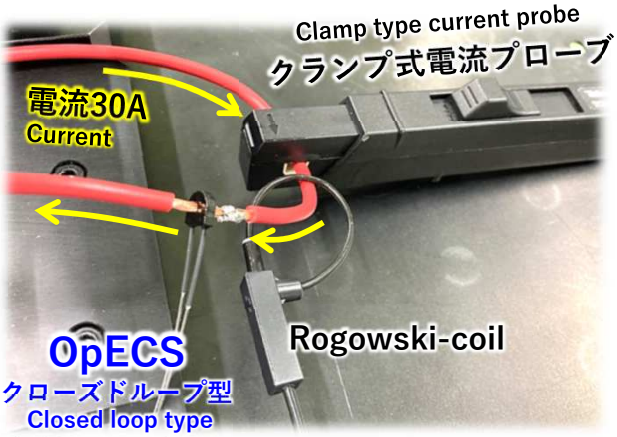
High permeability
Soft magnetic properties
Compatible with MHz band



Confine eddy currents within iron particles
鉄粒子内に渦電流を閉じ込め
＝渦電流損を抑制
Suppresses eddy currents

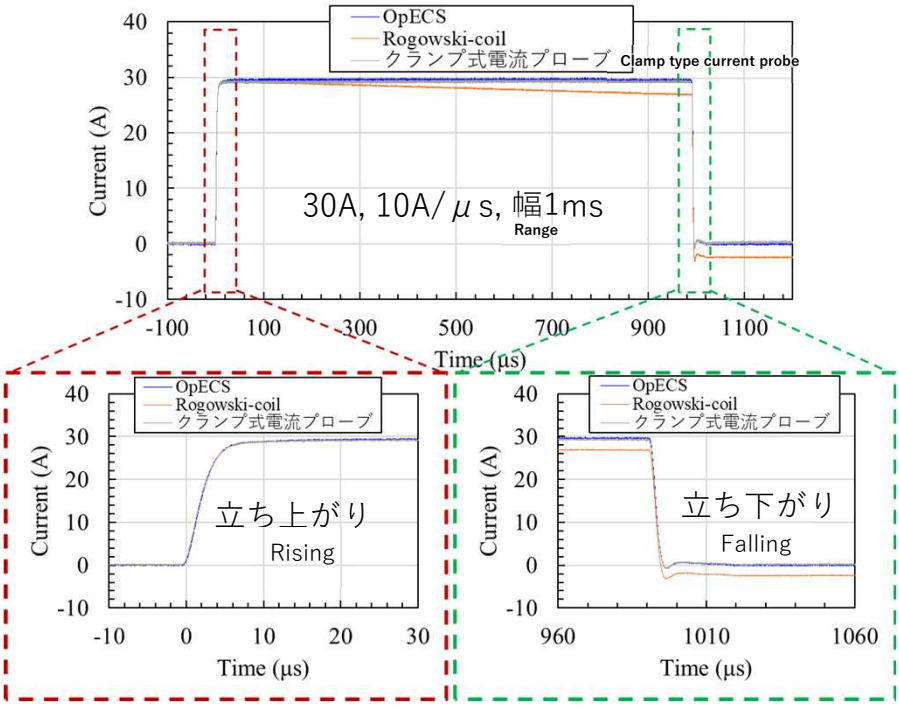


Closs section SEM image



△ Rogowski-coilはDC帯域が無い
○ OpECSとクランプ式電流プローブの波形は一致
○ OpECSは数100Aの大電流も計測可能

△ Rogowski-coil cannot measure DC
○ OpECS and clamp type current probe waveforms match
○ OpECS can measure high currents of several hundred A



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