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Laboratory for Nanoelectronics and Spintronics
Research Institute of Electrical Communication
Tohoku University

2013

施設研究報告書 2013
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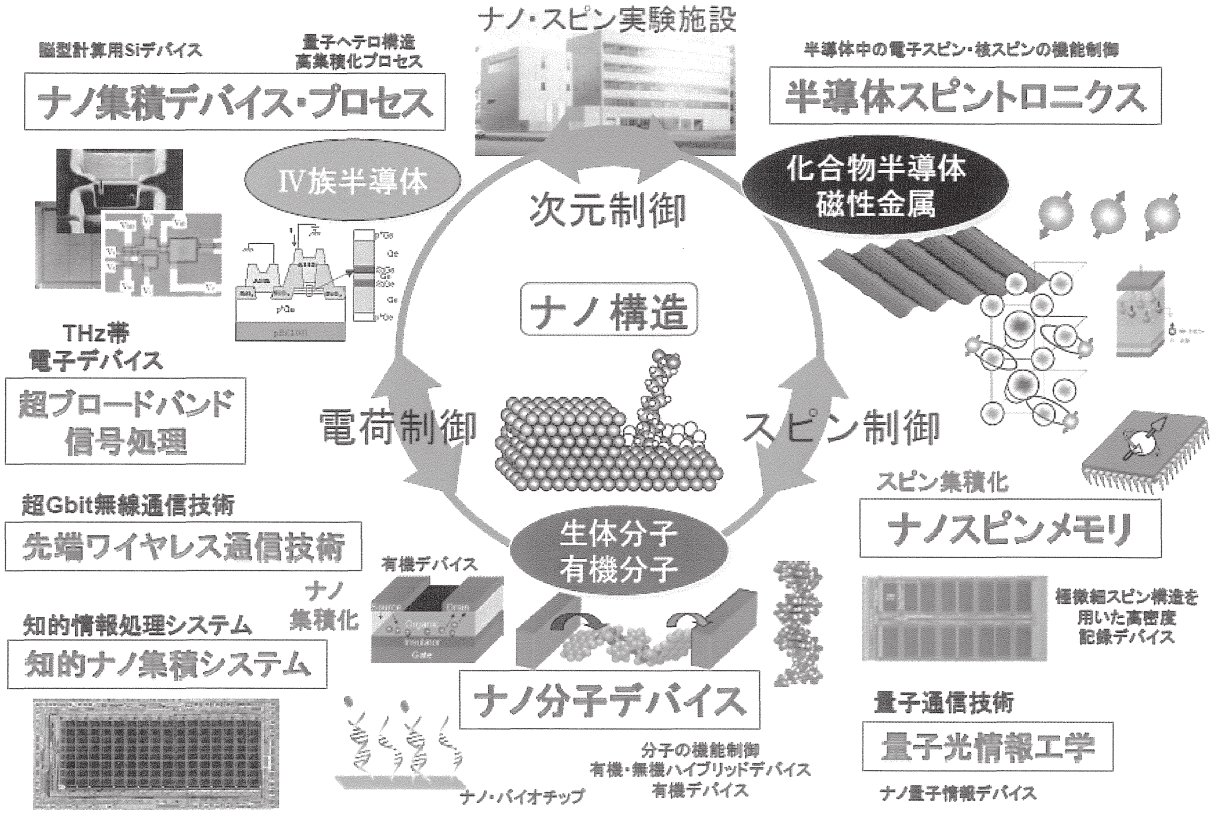
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1. 施設の概要
Outline

ナノ・スピン実験施設

～情報通信を支えるナノ・スピン基盤技術の創生～



「ナノ・スピン実験施設」は、本研究所附属研究施設として平成１６年４月１日に設置された。その目的は、情報通信を支えるナノエレクトロニクス・スピントロニクス基盤技術を創生することにある。これを実現するため、「ITプログラムにおける研究開発推進のための環境整備」によって整備されたナノ・スピン総合研究棟とその主要設備を用いて、本研究所および本所と密接な関係にある本学電気・情報系の各研究分野と共にナノテクノロジーに基づいた電子の電荷・スピンを駆使する基盤的材料デバイス技術の研究開発を進め、さらに全国・世界の電気通信分野の研究者の英知を結集した共同プロジェクト研究を推進する。

現在、ナノ・スピン総合研究棟では、「ナノ・スピン実験施設」が推進するナノヘテロプロセス、半導体スピントロニクス、ナノ分子デバイスの各基盤技術を担当する施設研究室と施設共通部、及び知的ナノ集積システム研究室、量子光情報工学研究室、超ブロードバンド信号処理研究室が入居し連携して研究を進めている。これらの陣容で、上記基盤技術を創生し、ナノエレクトロニクス・スピントロニクスにおける世界のCOEとなることを目標としている。

東北大学電気通信研究所附属
ナノ・スピン実験施設長
教授　　庭野　道夫

2. 施設の組織
Organization

電気通信研究所教授会
Faculty Council Research Institute of Electrical Communication

施設長（併任） Director
教授　庭野　道夫
Michio Niwano, Professor

共通部 Technical Office
技術職員　岩見友里香
Yurika Iwami, Technical Staff
技術職員　森田　伊織
Iori Morita, Technical Staff
非常勤研究員　西村容太郎
Youtaro Nishimura, Research Fellow

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委員長 施設長 Chair：教授　庭野　道夫
Michio Niwano, Professor
委　員 Member：教授　大野　英男
Hideo Ohno, Professor
教授　佐藤　茂雄
Shigeo Sato, Professor
教授　中島　康治
Koji Nakajima, Professor
教授　尾辻　泰一
Taichi Otsuji, Professor
教授　村岡　裕明
Hiroaki Muraoka, Professor
教授　長　康雄
Yasuo Cho, Professor
教授　鷲尾　勝由
Katsuyoshi Washio, Professor
教授　佐橋　政司
Masashi Sahashi, Professor
教授　末光　眞希
Maki Suemitsu, Professor

利用委員会

（平成25年度）

拡大実行委員会 Extended Executive Committee

実行委員会
施設教授　庭野　道夫
Michio Niwano, Professor
施設教授　大野　英男
Hideo Ohno, Professor
施設教授　佐藤　茂雄
Shigeo Sato, Professor

教授　中島　康治
Koji Nakajima, Professor
教授　枝松　圭一
Keiichi Edamatsu, Professor
教授　尾辻　泰一
Taichi Otsuji, Professor



岩見友里香 技術職員 Yurika Iwami Technical Staff
庭野　道夫 (施設長) 教授 Michio Niwano Director, Professor
西村容太郎 非常勤研究員 Youtaro Nishimura Research Fellow
森田　伊織 技術職員 Iori Morita Technical Staff

3. 平成 24 年度の研究成果のハイライト

Highlights of Research in FY2012

施設研究部と利用研究室の平成 24 年度の研究成果のハイライトを記します。

ナノ集積基盤技術関連

Nano Integration

● ナノ集積デバイス・プロセス（佐藤茂雄・櫻庭政夫）
Nano-Integration Devices and Processing (S. Sato and M. Sakuraba)

(1) 組合せ最適化問題等を効率的に解くことができる神経回路の電子回路設計を行った。乗算器を AND ゲートで代替することが可能な確率的ロジックを用いて、デジタル回路として構成し、FPGA を用いて実装した。またシナプス荷重値メモリを節約するための手段として、動的に荷重値を生成する方法を考案しその有効性を確認した。さらに、超伝導量子ニューロンを構成するために、これまでに提案されている超伝導量子ビットの量子特性を解析した。デコヒーレンスを引き起こす要因をシミュレーションによって検証し、状態制御方法やバイアス方式など多ビット化に向けてデバイスデザインに関する指針を得た。

(2) 基板非加熱 ECR プラズマ CVD 装置によるエピタキシャル成長について研究を進め、基板非加熱下での Si(100)上への $Si_{1-x}Ge_x$ 薄膜形成において、SiH_4 ガスと GeH_4 ガスの混合比率を変えることにより、広い範囲で Ge 比率制御できることを見いだした。また、基板非加熱下での高濃度 B ドープ Si のエピタキシャル成長に成功し、200～300°C での低温熱処理によりキャリア濃度 10^{18} cm^{-3} を超える低抵抗 B ドープ Si エピタキシャル薄膜形成を可能とした。さらに、Si(100)上に B 濃度が 5%をはるかに超える高 B 濃度 B ドープ Ge 薄膜のエピタキシャル成長を可能にした。

(1) Digital neural network circuit using stochastic logic has been designed and implemented on an FPGA for its application to combinatorial optimization problems. We calculate synaptic weights dynamically and do not store such weights to save memory usage, and confirm such technique works successfully. Moreover, we have analyzed quantum properties of superconducting qubits proposed so far in order to implement a qubit or a quantum neuron. Research direction for device design including quantum state control and biasing has been obtained for multi-bit implementation.

(2) Epitaxial growth using low-energy ECR plasma CVD without substrate heating has been studied. It is found that Ge fraction in $Si_{1-x}Ge_x$ alloy films on Si(100) can be controlled widely by change of reactant gas flow ratio of SiH_4 and GeH_4. Moreover, epitaxial growth of B-doped Si films with extremely high B concentration has been enabled, and carrier concentration higher than 10^{18} cm^{-3} can be obtained by low-temperature heat treatment at 200-300°C after depostion. Additionally, epitaxial growth of B-doped Ge films with higher B concentration than 5% has been enabled on Si(100).

● 知的ナノ集積システム（中島康治）
Intelligent Nano-Integration System (K.Nakajima)

(1) 生体神経細胞に見られるバースト発火現象を表現する方程式をアクティブ領域を持つポテンシャル上の疑似粒子運動という新概念を用いて解析し各種バースト発振のパラメータ依存性を解析した。また高次シナプス結合を持つ逆関数遅延ニューロンモデルが最適解へ収束する条件を理論的に導出し、数値実験により実証した。その結果を災害時断絶ネットワーク対応の移動ノードスケジューリングへ適用しその有効性を示した。さらに上記モデルを用いた最適化問題や連想記憶などの高速数値解析を実現する逆関数ゼロ遅延モデルを提案し、その有効性を確認するとともに FPGA によるハードウェア化へと展開した。(2) 超伝導量子ビット構成のためのジョセフソン接合スイッチング特性の解析を引き続き進め、超伝導集積回路シミュレータ JSIM を使った結果やこれまでの実験結果を検討し、多ビット化の方向性を探った。これに基づいた量子コンピュータの設計を進めている。(3) 超伝導ディジタル信号処理回路の

大規模化と高バイアスマージン化を目的とし、レイテンシを高めた 8 x 8 ビット並列乗算器の新たな設計を行い、集積回路製作のための CAD パターンを構成した。また、超伝導量子干渉デバイスによるニューロ素子を利用したホップフィールド形ネットワークを構成し、集積回路によるニューロン回路の基礎特性の実測を行った。さらに従来の単一磁束量子に基づくパルス論理とは異なるレベル論理方式を提案し、その有効性と動作マージンについて検討を進めた。

(1) By using high-order synapses for an inverse function delayed neural network, we theoretically obtained the parameter values that presented optimal solutions only for traveling salesman and quadratic assignment problems. Furthermore, we proposed a generalized energy function for scheduling problems and an inverse function delay-less model for high speed numerical calculation of artificial neural networks. (2) We also proposed new analyses based on the relationship among a potential and active regions for nonlinear dynamics, in which bursting oscillations were analyzed and designed. (3) We studied a possibility of superconducting plural bits realization in the quantum bits computation algorithm. We demonstrated successfully a 4-bit parallel multiplier using a carry look-ahead adder with niobium integrated circuits to improve the performance of high-speed operation for the single flux-quantum fast Fourier transform and designed an 8-bit parallel multiplier. A neural network using superconducting quantum interference devices was fabricated and successfully demonstrated.

半導体スピントロニクス基盤技術関連

Semiconductor Spintronics and information technology

● 半導体スピントロニクス・ナノスピンメモリ（大野英男・池田正二）
Semiconductor Spintronics and Nano-Spin Memory
(H. Ohno and S. Ikeda)

固体中のスピンと電荷の自由度を使ったスピントロニクスの基盤技術の確立とその工学的応用を目的として研究を行い、以下の成果を得た。(1) GaAs 量子井戸において、^{75}As の核スピンを電界によってコヒーレントに制御することに成功し、核スピンを利用した量子コンピューティングへの応用の道を開いた。(2) 垂直磁化容易 CoFeB-MgO 磁気トンネル接合(CoFeB/MgO p-MTJ)において、低消費電力な p-MTJ の書き込み方法として期待される電界磁化反転に成功した。(3) 磁壁移動素子の基本構造である垂直磁化容易 Ta/CoFeB/MgO 構造において、MgO 層表面の Ar イオンミリングによる局所的な磁気異方性の制御方法を明らかにした。(4) 不揮発性 VLSI への応用が期待される CoFe(B)/MgO 接合において磁気異方性の B 組成依存性を調べ、CoFeB/MgO p-MTJ における材料設計の指針を得た。(5) CoFeB/MgO p-MTJ において、ニュークリエーションサイズ以上で熱安定性指数Δは記録層厚に比例することを実験的に示し、CoFeB/MgO p-MTJ の素子設計の指針を得た。(6) CoFeB-MgO p-MTJ において、MgO/CoFeB/Ta/CoFeB/ MgO 構造を記録層に適用することにより、スピン注入磁化反転の閾値電流密度の増加を抑えながら高い熱安定性(Δ = 95 @70nm 直径)を実現することに成功し、不揮発性 VLSI の高集積化に向け道を開いた。

・連携研究

1. 日本学術振興会「省エネルギー・スピントロニクス論理集積回路の研究開発」において、参画研究室と連携して以下の成果を得た。(1) 2 重 CoFeB-MgO 界面記録層と積層フェリ参照層を開発し、直径 29nmϕ磁気トンネル接合(MTJ)で熱安定性指数Δ = 59 を得た。(2) $L1_0$ 型 MnAl 規則合金電極 MTJ において、室温で初めて TMR 効果を観測した。(3) 100%以上の磁気抵抗比を示す 40 nm 径 CoFeB-MgO 垂直 MTJ において、1 ns 以下の高速スイッチング動作を確認した。(4) 細粒度パワーゲーティングを適用した 1Mb STT-RAM、及び画像処理演算回路を試作した。(5) 4T-2MTJ 不揮発 TCAM (ternary content-addressable memory)セル回路を試作し基本動作を確認した。

2. 文部科学省「次世代 IT 基盤構築のための研究開発」の委託研究である「耐災害性に優れた安心・安全社会のためのスピントロニクス材料・デバイス基盤記述開発」プロジェクトにおいて、参画研究室と連携して以下の成果を得た。(1) 放射線照射実験用の p-MTJ チップを作製した。(2) 高速スイッチング測定用の素子を作製した。

Our research activities focus on the establishment of fundamental technologies for future spintronics devices. The outcomes in the last fiscal year are following. (1) Demonstration of coherent control of nuclear spins with an electric field, focusing on ^{75}As as a target nucleus. (2) Demonstration of electric field-induced ~180° magnetization reversal in a CoFeB/MgO based magnetic tunnel junction with a perpendicular magnetic easy axis (p-MTJ). (3) Demonstration of spatial control of the magnetic anisotropy of perpendicularly magnetized CoFeB/MgO films by etching a fraction of the MgO overlayer. (4) B composition dependence of magnetic anisotropy in MgO/CoFe(B) stack structures was clarified. (5) Discovery of proportionality between thermal stability factor and thickness of a recording layer in p-MTJ with the size larger than nucleation diameter. (6) Development of p-MTJs with a double interface MgO/CoFeB/Ta/CoFeB/MgO recording structure.

1. Research activities in "Research and development of ultra-low power spintronics-based VLSIs" under granted by JSPS through the FIRST program. (1) Development of a CoFeB based p-MTJ with 29 nm in diameter, which shows thermal stability factor of 59, by using a double interface MgO/CoFeB/Ta/CoFeB/MgO recording layer and synthetic ferrimagnetic reference layer. (2) Observation of tunneling magnetoresistance at room temperature in p-MTJ with $L1_0$-ordered MnAl electrodes. (3) Demonstration of high speed switching less than 1 ns in p-MTJ with 40 nm in diameter. (4) Fabrication of 1Mb STT-RAM and image processing circuit based on fine-grain power gating. (5) Fabrication and verification of basic operation of 4T-2MTJ nonvolatile ternary content-addressable memory (TCAM) cell.
2. Research activities in "Research and Development of Spintronics Material and Device Science and Technology for a Disaster-Resistant Safe and Secure Society" program under Research and Development for Next- Generation Information Technology of MEXT. (1) Fabrication of p-MTJs for irradiation experiment. (2) Fabrication of spintronics devices for high-speed switching measurement.

● 超ブロードバンド信号処理（尾辻泰一･末光哲也）
Ultra-Broadband Signal Processing (T.Otsuji and T.Suemitsu)

未踏テラヘルツ電磁波領域の技術を開拓するために、新材料・新構造・新原理を駆使した新しいテラヘルツ帯電子デバイス・回路システムの創出と、それらの情報通信・計測システムへの応用に関する研究を推進している。今年度は、第一に、単原子層炭素材料：グラフェンを利得媒質としてその特異なキャリア輸送特性を活用した新原理テラヘルツレーザーを提案し、室温における誘導放出の原理検証成功に続き、表面プラズモンポラリトンによる巨大利得増強作用を理論的に発見した。第二に、プラズモン共鳴を原理とする超高感度・低雑音テラヘルツ波検出・コヒーレントテラヘルツエミッターデバイスの開発に成功し、室温動作では自らの世界最高感度記録を更新（1.5 THz 入射時に 6.4 kV/W の検出感度）するとともに、プラズモンでは初のコヒーレント CW 発振に成功した。

The goal of our research is to explore the terahertz frequency range by creating novel electron devices and systems. Graphene, a monolayer sheet of honeycomb carbon crystal, exhibits unique carrier transport properties owing to the massless and gapless energy spectra, which is expected to break through the limit on conventional device operating speed/frequency performances. First, we have theoretically discovered giant gain enhancement of surface plasmon polaritons in THz range in population-inverted graphene, monolayer of carbon atomic honeycomb crystal, by whose extraordinary carrier transport properties we proposed a novel THz lasers and experimentally verified stimulated THz emission at room temperature. Second, we devised novel plasmon-resonant THz emitter/detector devices, succeeding in world-first coherent monochromatic THz plasmonic lasing and breaking the record sensitivity to 6.4 kV/W at 1.5-THz radiation.

● 量子光情報工学（枝松圭一・小坂英男・三森康義）
Quantum-Optical Information Technology (K.Edamatsu, H.Kosaka and Y,Mitsumori)

1. 多光子量子もつれ光子対の発生・制御・検出方法の開発

量子相関をもった光子対の発生とその利用技術は、量子情報通信技術の最も重要な要素の一つである。本研究室では、半導体や擬似位相整合非線形光学結晶を用いた量子もつれ光子の発生・検出方法について研究している。本年度は、(1) 4 光子間束縛量子もつれ状態の活性化の実証（Phys. Rev. Lett.誌に発表）、(2)通信波長帯における多光子量子干渉の実証（Phys. Rev. A 誌に発表）、 (3) シリコン細線導波路における高効率光子対発生、等の成果を得た。

2. 量子中継のための量子メディア変換デバイスの開発
量子情報通信における通信距離を飛躍的に増大するための量子中継器の実現を目指し、情報伝送を担う光子がもつ量子情報を情報処理を担う電子スピンへと転写する量子メディア変換インターフェース技術の開発を進めている。本年度は、(1)光子から電子スピンへの状態転写過程の忠実度をトモグラフィ測定するにより転写が量子的であることを明らかにした（投稿中)、(2) ダイヤモンド量子ビットへの光量子状態転写の基礎実験、等の成果を得た。
3. 半導体量子ドットの超高速コヒーレント制御
半導体量子ドット中の電子状態のラビ振動によるコヒーレント制御法の開発は量子情報処理を目指す固体デバイスを実現する上で必要不可欠な技術開発である。本年度は、フォトンエコー法を用いて励起子ラビ振動を観測し、量子ドットの新しい光学効果である局所電場効果を観測した（投稿中)。

1. We are developing novel and efficient entangled-photon sources. We have demonstrated (1) generation and activation of four-photon bound entanglement, (2) quantum multi-photon interference in telecom wavelength, and (3) efficient photon pair generation from silicon wire waveguides.
2. We are developing a quantum media converter from a photon to an electron spin to realize a quantum repeater, which is expected to extend the transmission distance of quantum info-communication. We have demonstrated that (1) the process of state transfer is quantum like by the measurement of electron spin state tomography, and (2) fundamental experiments for the photonic state transfer to a quantum memory in diamond.
3. We have investigated the excitonic Rabi oscillations in semiconductor quantum dots using photon echo spectroscopy for the development of the optical coherent control of the electric states in the quantum dots. We have observed the interesting behavior of the Rabi oscillations arising from the local field effect in the quantum dots.

ナノ分子デバイス基盤技術関連

Nano-Molecular Devices

● ナノ分子デバイス（庭野道夫・木村康男）
Nano-Molecular Devices (M. Niwano and Y. Kimura)

1. チタンの陽極酸化過程の解明
チタンの陽極酸化技術は、垂直配向した酸化チタンナノチューブを作製する有効な手法であり、電解液としてフッ化アンモニウムを含む有機電解液が用いられる。その形成過程や形成される酸化チタンナノチューブの構造はその電解液の組成に強く影響を受ける。電解液に含まれるフッ化アンモニウム及び水の濃度を変化させ、それらとチタンの陽極酸化速度との関係を詳細に分析することにより、水とフッ化アンモニウムの濃度比が形成過程に重要な役割を果たしていることを解明した。これは、電解液により酸化チタンナノチューブの構造制御が可能であることを示している（JES 誌に発表)。
2. 局所陽極酸化による微小 TiO_2 ガスセンサの作製
フォトリソグラフィ技術と陽極酸化技術を組み合わせた局所陽極酸化により、2 μm×2 μm という微小 TiO_2 ガスセンサが作製可能であることを示した。また、ナノチューブ壁の厚さを薄くすることによりその感度やリニアリティを向上できることを示した。これらは、微細加工技術と陽極酸化技術を組み合わせることにより微小ガスセンサが作製可能であることを示しており、ガスセンサの低消費電力化及び多成分同時測定可能な集積化ガスセンサの構築が期待される（Sens. and Actuators B 誌に発表)。
3. 半導体基板上に作製した人工脂質二分子膜への hERG チャネルの包埋
シリコン基板上に作製した微細孔中に高安定性の人工細胞膜を形成し、その中に生体から抽出した hERG チャネルタンパク質を包埋した結果、hERG の単一チャネル電流を明瞭に記録することに成功した。hERG チャネルは創薬初期段階における副作用評価が必須のタンパク質であり、この結果は、活性を保持した状態でシリコンチップ中に hERG チャネルを包埋できることを示している。今後は、ハイスループット副作用評価チップ等の薬物スクリーニングへの応用が期待さ

れる（Anal. Chem.誌に発表）。

1. Elucidation of anodization process of titanium

The anodization process of Ti is a useful method to form vertically oriented TiO_2 nanotube films and an ammonium fluoride (NH_4F) containing organic solution is used as an electrolyte. The formation process and the structure of anodic TiO_2 nanotubes depend strongly on component of electrolyte. We investigated influence of concentrations of NH_4F and water in the organic electrolyte on the growth rate of TiO_2 nanotube films. We found that a ratio of the concentration of NH_4F to that of water plays an important role in the anodization process of Ti. This indicates that the structure of anodic TiO_2 nanotubes can be controlled by an electrolyte. (published in JES)

2. Fabrication of micro TiO_2 gas sensors through local anodization.

We demonstrated fabrication of micro gas sensor of 2×2 μm^2 through local anodization which is a hybrid process between the photolithography technique and the anodization process. The sensitivity and the linearity were improved by thinning walls of anodic TiO_2 nanotubes. This indicates that the local anodization is a suitable method for miniaturization of gas sensors and reduction in power consumption and development of a simultaneous multi-component gas sensing system are expected. (published in Sens. and Actuators B)

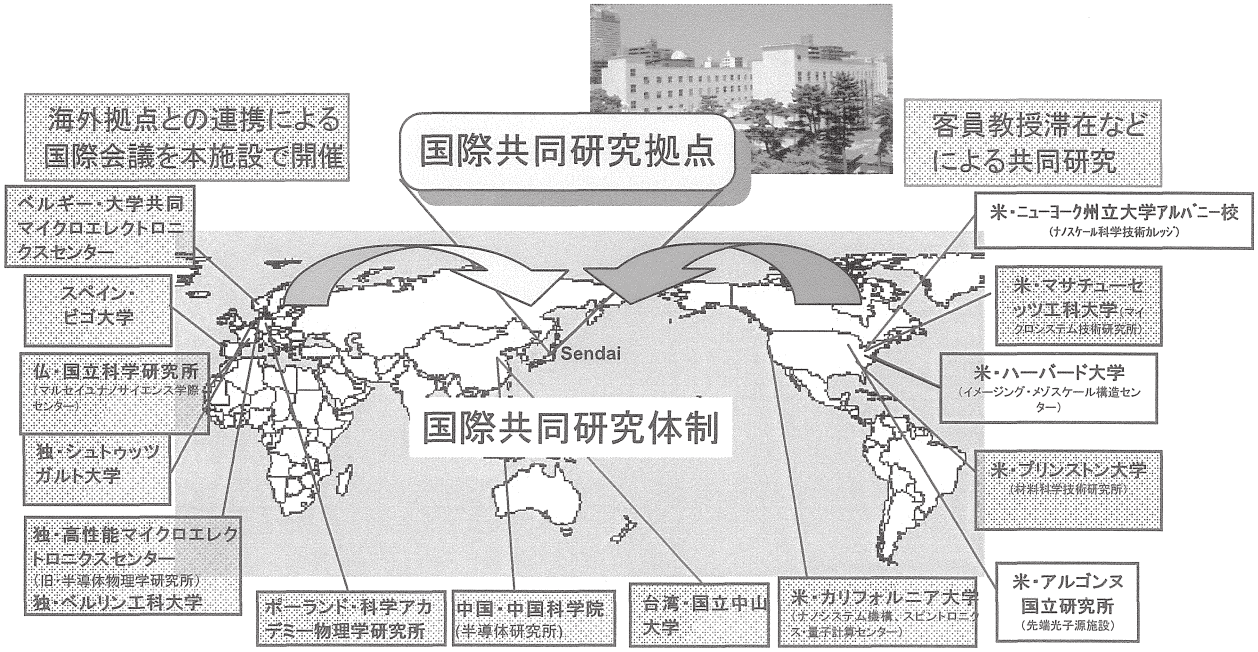
3. Reconstitution of hERG channels in microfabricated Si chips

We have succeeded in reconstitution of human *ether-a-go-go*-related gene (hERG) channels in stable bilayer lipid membranes (BLMs) formed in micropores fabricated in Si chips. Characteristic features of hERG channels, including single-channel conductance and sensitivity to typical drugs, were observed, demonstrating intact incorporation of hERG in the Si chips. The hERG channel has been drawing a lot of pharmacological attention because it has been found to cause serious arrhythmic side effects. The next step is to extend the hERG-containing stable BLM device to a multi-site array format. The realization of a hERG-channel array will open a variety of applications, including high-throughput drug safety screening procedures. (published in Anal. Chem.)

4. 施設の活動

4－1　ナノエレクトロニクス国際共同研究拠点の創出

平成 17 年度～21 年度特別教育研究経費として採択されたナノエレクトロニクス国際共同研究拠点創出事業を基盤として、21 世紀に求められる高度な情報通信を実現するため、「半導体立体ナノ構造の実現と応用」、「半導体中のスピン制御技術の確立と応用」、「分子ナノ構造による情報処理の実現と応用」の 3 本を柱に据え、ナノエレクトロニクス情報デバイスと、これを用いた情報システムの構築を推進するとともに、これらを実現するための国際共同研究体制を構築し、ナノエレクトロニクス分野の世界におけるセンターオブエクセレンスの確立を目指している。



大学間協定　独・ベルリン工科大学
米・ハーバード大学

部局間協定　独・高性能マイクロエレクトロニクスセンター
仏・国立科学研究所マルセイユナノサイエンス学際センター
中国・中国科学院半導体研究所
ポーランド・科学アカデミー
スペイン・ビゴ大学
台湾・国立中山大学

大学間覚書　米・ニューヨーク州立大学アルバニー校ナノスケール科学技術カレッジ
米・カリフォルニア大学　サンタ・バーバラ校

ナノ・スピン実験施設で開催した国際シンポジウム

RIEC Symposium on Spintronics
(第1回: 2005年2月8- 9日， 第2回：2006年2月15-16日，
第3回：2007年10月31日-11月1日，第4回：2008年10月9-10日，
第5回：2009年10月22-23日， 第6回：2010年2月5-6日，
第7回：2011年2月3-4日， 第8回：2012年2月2-3日，
第9回：2012年5月31-6月2日，第10回：2013年1月15-16日，
第11回：2013年1月31-2月1日)
International Workshop on Nanostructure & Nanoelectronics
(第1回: 2007年11月21- 22日，第2回：2010年3月11-12日，
第3回：2012年3月21-22日，第4回：2013年3月7-8日)
RIEC-CNSI Workshop on Nano & Nanoelectronics 、Spintronics and Photonics
(第1回: 2009年10月22- 23日)
RIEC International Symposium on Brain Functions and Brain Computer
(第 1 回：2012 年 11 月 15-16 日)


3rd Int. Workshop on New Group IV Semiconductor Nanoelectronics


2nd RIEC Symposium on Spintronics-MgO-based Magnetic Tunnel Junction-Left: Albert Fert (received 2007 Nobel Prize in Physics); Right: Russel Cowburn

4－2 国際シンポジウム開催 （プログラムは「6．参考資料」に収録）

第 46 回電気通信研究所国際シンポジウム

第 9 回 RIEC スピントロニクス国際ワークショップ
The 9th RIEC International Workshop on Spintronics

大野　英男
Hideo OHNO

開 催 日: 平成 24 年 5 月 31 日～6 月 2 日（3 日間）
開催場所:東北大学電気通信研究所　ナノ・スピン実験施設

2012 年 5 月 31 日、6 月 1－2 日に、本学電気通信研究所が主催する標記国際ワークショップが附属ナノ・スピン実験施設において開催された[組織委員長：通研・大野英男教授]。参加者 113 名の内、国外からの参加者は 33 名を数えた。アメリカ、イギリス、オランダ、サウジアラビア、ドイツ、フランス、ポーランド、中国、韓国、日本の計 10 カ国から 22 名の研究者を招待講演者として迎えた。ポスターセッションでは、オランダ、ドイツ、日本から 17 件の一般講演があった。本ワークショップでは非磁性半導体、強磁性半導体、非磁性金属におけるスピンに関連した基礎物性から、それらを利用した素子特性など幅広い話題に関して活発に議論された。これらの発表・議論を通して、スピントロニクスの研究動向と将来の方向性が明らかとなり有意義なワークショップとなった。また、ポスター発表を含め多くの学生の参加もあり、学生の国際性を育む機会の提供という観点からも大きな成果を得ることができた。

第 49 回電気通信研究所国際シンポジウム

第 1 回 脳機能と脳型計算機に関する通研国際シンポジウム
The 1st RIEC International Symposium on Brain Functions and Brain Computer

佐藤　茂雄
Shigeo SATO

開 催 日：平成 24 年 11 月 15 日（木）～16 日（金）（2 日間）
開催場所：東北大学電気通信研究所　ナノ・スピン実験施設

本シンポジウムは、半導体工学、計算機工学、ロボット工学、数理工学、大脳生理学、神経科学、心理物理学、非線形物理学といった関連分野から広く研究者を集め、脳機能や脳型計算機に関する最近の成果・動向について、分野の垣根を超えて研究発表と議論を行うことを目的として企画・設立された。今回が初回であり、平成 24 年 11 月 15 日、16 日の 2 日間に渡って開催された。シナプス可塑性に関する研究において世界的権威である Bliss 博士を含む 3 か国 4 名の海外招待講演者を迎え、計 11 件の講演が行われた。講演内容は、神経科学、培養神経回路、集積回路など多岐にわたるものであったが、分野を超えて有意義な質疑応答が活発に行われた。シンポジウムは終始アットホームな雰囲気で開催され、参加者同士の情報共有・連携強化に資するものとなり、成功裏に終了した。

第 50 回電気通信研究所国際シンポジウム

Tohoku-Harvard Joint Workshop
New Directions in Materials for Nanoelectronics, Spintronics and Photonics
(The 10th RIEC International Workshop on Spintronics)

大野　英男
Hideo OHNO

開 催 日: 平成 25 年 1 月 15 日～16 日（2 日間）
開催場所:東北大学電気通信研究所　ナノ・スピン実験施設

2013 年 1 月 15 日、16 日に、本学電気通信研究所が主催する標記国際ワークショップが附属ナノ・スピン実験施設において開催された[組織委員長：通研・大野英男教授、本学原子分子材料科学高等研究機構との共催、本学電気通信研究所での 10th RIEC International Workshop on Spintronics（1 月 15 日、16 日）とのジョイント開催]。参加者 73 名の内、国外からの参加者は 10 名を数えた。ハーバード大学(関連大学を含む)と本学の交流を深め、共同研究への展開を図ることを目的として、両大学(ハーバード大学 9 名、本学 8 名)の代表者が、現在取り組んでいる研究について講演した。ポスターセッションでは 17 件の一般講演があった。ナノエレクトロニクス、スピントロニクス、フォトニクスに関する幅広い話題が活発に議論された。この議論を通じ、ハーバード大学と本学間の相互連携の研究課題がより明確となり、有意義なワークショップとなった。また、多くの学生の参加もあり、学生の国際性を育む場としても大きな成果を得ることができた。

第 51 回電気通信研究所国際シンポジウム

第 11 回 RIEC スピントロニクス国際ワークショップ
The 11th RIEC International Workshop on Spintronics

大野　英男
Hideo OHNO

開 催 日: 平成 25 年 1 月 31 日～2 月 1 日（2 日間）
開催場所:東北大学電気通信研究所　ナノ・スピン実験施設

2013 年 1 月 31 日、2 月 1 日の両日に、本学電気通信研究所が主催する標記国際ワークショップが附属ナノ・スピン実験施設において開催された[組織委員長：通研・大野英男教授、本学省エネルギー・スピントロニクス集積化システムセンターでの 3rd CSIS International Symposium on Spintronics-based VLSIs（1 月 31 日、2 月 1 日）とのジョイント開催]。参加者 127 名の内、国外からの参加者は 30 名を数えた。アメリカ、フランス、韓国、日本から 20 名の研究者を招待講演者として迎えた。ポスターセッションでは、台湾、日本から 22 件の一般講演があった。本ワークショップではスピン注入磁化反転、磁壁移動、電界効果磁化反転などのスピントロニクス材料・素子の基本特性から、それらを利用した不揮発性メモリ・論理集積回路の実証まで幅広い話題に関して活発に議論された。これらの発表・議論を通じ、スピントロニクス集積回路における省エネルギー化および高性能化の重要性と、更なる微細化・高集積化に対する研究課題が明確になり、将来の研究開発の方向性を示す有意義なワークショップとなった。また、ポスター発表を含め多くの学生の参加もあり、学生の国際性を育む機会の提供という観点からも大きな成果を得ることができた。

第 52 回電気通信研究所国際シンポジウム

第 7 回バイオ･医療･ナノエレクトロニクスに関する国際シンポジウム、第 4 回ナノ構造とナノエレクトロニクスに関する国際ワークショップ及び JSPS 先端研究拠点事業合同セミナー“ULSI のための原子制御プロセス”との合同シンポジウム”
The Joint Symposium of 7th International Symposium on Medical, Bio- and Nano-Electronics, 4th International Workshop on Nanostructures & Nanoelectronics, and JSPS Core-to-Core Program Joint Seminar "Atomically Controlled Processing for Ultralarge Scale Integration"3rd International Workshop on Nanostructures & Nanoelectronics

庭野　道夫
Michio NIWANO

開 催 日: 平成 25 年 3 月 7 日～8 日（2 日間）
開催場所: 東北大学電気通信研究所　ナノ・スピン実験施設

平成 25 年 3 月 7、8 日の 2 日間にわたり、3 つの国際シンポジウムの合同シンポジウムを東北大学電気通信研究所ナノ・スピン実験施設にて開催した。海外(ドイツ、韓国、アメリカ、スペイン)から 10 名、日本から 7 名の招待講演者及び学内から 5 名の一般講演者によって、実験方法の詳細や結果など最新の研究成果が紹介された。その内容は、グラフェンの形成手法やその特性、陽極酸化を利用した酸化チタンナノチューブ形成技術、金属ナノ粒子の電気化学的堆積法、酸化物半導体及び金属からなるナノ粒子の光電気化学的効果、半導体膜堆積技術やプラズマ医療応用など、基礎研究からそれらの応用まで多岐にわたり、様々な分野からの発表及び議論が活発になされた。また、8 日午後にポスターセッションを開催し、研究者間の交流がなされた。参加人数は、87 名を数え、活発で有意義な討論及び情報交換が行われた。これらの知見及び広い分野の研究者の交流は，ナノエレクトロニクスやそれらの医療応用など，今後の研究の進展に大いに貢献すると考えられる。

5．研究成果（平成 24 年度）

5A　ナノ集積基盤技術関連

Nano Integration

A1　ナノ集積デバイス・プロセス（佐藤茂雄・櫻庭政夫）

Nano-Integration Devices and Processing
(S. Sato and M. Sakuraba)

A2　知的ナノ集積システム（中島康治）

Intelligent Nano-Integration System
(K.Nakajima)

A1　ナノ集積デバイス・プロセス（佐藤茂雄・櫻庭政夫）
Nano-Integration Devices and Processing (S. Sato and M. Sakuraba)

1. **脳型計算用デバイスの高密度実装技術に関する研究**
   High-density implementation of devices for brain computing

   組合せ最適化問題等を効率的に解くことができる神経回路の電子回路設計を行った。乗算器を AND ゲートで代替することが可能な確率的ロジックを用いて、デジタル回路として構成し、FPGA を用いて実装した。またシナプス荷重値メモリを節約するための手段として、動的に荷重値を生成する方法を考案しその有効性を確認した。
   Digital neural network circuit using stochastic logic has been designed and implemented on an FPGA for its application to combinatorial optimization problems. We calculate synaptic weights dynamically and do not store such weights to save memory usage, and confirm such technique works successfully.

2. **脳型計算用量子知能デバイスに関する研究**
   Intelligent quantum device for brain computing

   超伝導量子ニューロンを構成するために、これまでに提案されている超伝導量子ビットの量子特性を解析した。デコヒーレンスを引き起こす要因をシミュレーションによって検証し、状態制御方法やバイアス方式など多ビット化に向けてデバイスデザインに関する指針を得た。
   We have analyzed quantum properties of superconducting qubits proposed so far in order to implement a qubit or a quantum neuron. Research direction for device design including quantum state control and biasing has been obtained for multi-bit implementation.

3. **高度歪 IV 族半導体エピタキシャル成長のための低損傷基板非加熱プラズマ CVD プロセスに関する研究**
   Low-damage plasma CVD process without substrate heating for epitaxial growth of highly strained group IV semiconductors

   ナノメータオーダ厚さの高品質量子ヘテロ構造を実現するために、原子オーダで平坦かつ急峻なヘテロ界面を有する高度歪 IV 族半導体薄膜のヘテロエピタキシャル成長について研究している。
   In order to realize nanometer-order thick high-quality heterostructure, heteroepitaxial growth of highly strained group-IV semiconductor films with atomically flat and abrupt heterointerfaces is being studied.

4. **IV 族半導体高度歪量子ヘテロ構造の高集積化プロセスに関する研究**
   Large-scale integration process of group IV semiconductor quantum heterostructures

   IV 族半導体量子効果デバイスの Si 集積回路への搭載を実現するために、IV 族半導体高度歪量子ヘテロ構造の高集積化プロセスと量子ヘテロナノデバイス製作・高性能化について研究している。
   In order to integrate group-IV semiconductor quantum-effect devices into Si LSI, large-scale integration process of group-IV highly strained quantum heterostructures and farication of high-performance quantum hetero nanodevices are being studied.

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A2 知的ナノ集積システム（中島康治）
Intelligent Nano-Integration System (K.Nakajima)

1. **集積化ニューラルネットワークの基本構成と学習性能に関する研究**
   Research for basic architectures of LSI neural networks and theirs learning efficiency

   集積化ニューラルネットワークを用いた知的情報処理システムの構成法を追究し、その学習性能を評価・解析して性能向上を図る。
   This research is concerned with the design of intelligent information processing systems constructed of LSI neural networks. The fabricated LSI neural networks are analyzed and evaluated to improve the learning efficiency.

2. **逆関数遅延ネットワークモデルに関する研究**
   Research for inverse function delayed network models

   アクティブニューロンモデルである ID モデルを用いて、知的情報処理システムを目指す。
   This research is concerned with the development of the intelligent processing system by using ID models which are active neuron models.

3. **ニューロ的手法を利用した量子計算機に関する研究**
   Research for neuromorphic quantum computer

   ニューロ的手法を利用した量子計算アルゴリズムの開発と、その固体素子への実装を図る。
   This research is concerned both with the development of a new neuromorphic quantum computation algorithm and its implementation with solid state devices.

4. **超伝導位相モード集積回路に関する研究**
   Research for superconducting phase-mode LSI

   磁束量子を情報担体とする超伝導集積回路で構成した新しい計算機システムを開発する。
   This research is concerned with the development of new computer systems constructed of superconducting LSI circuits where single flux quanta are used as information bit carriers.

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5 B　半導体スピントロニクス基盤技術関連

Semiconductor Spintronics and information technology

B1　半導体スピントロニクス、ナノスピンメモリ（大野英男・池田正二）
Semiconductor Spintronics and Nano-Spin Memory
(H.Ohno and S.Ikeda)

B2　超ブロードバンド信号処理（尾辻泰一･末光哲也）
Ultra-Broadband Signal Processing
(T.Otsuji and T.Suemitsu)

B3　量子光情報工学（枝松圭一・小坂英男・三森康義）
Quantum-Optical Information Technology
(K.Edamatsu, H.Kosaka and Y,Mitsumori)

B1　半導体スピントロニクス、ナノスピンメモリ（大野英男・池田正二）
Semiconductor Spintronics and Nano-Spin Memory (H. Ohno and S. Ikeda)

固体中の電子やスピンの状態を制御し工学的に応用するために、新しい材料の開発、量子構造の作製と性質の理解、及びそれらのスピントロニク素子・高機能素子への応用に関する研究を行っている。さらに、不揮発性により、高機能かつ低消費電力化が期待されるスピントロニクス素子、及びスピントロニクス集積回路技術の研究開発を行っている。

Our research activities cover the areas of preparation, characterization, and application of new classes of solid state materials as well as their quantum structures, in which electronic and spin states can be controlled. Furthermore, we are working on research and development of advanced technology for spintronics-based devices and integrated circuits, which are expected to realize high performance and low power consumption owing to their nonvolatility.

1. 半導体スピントロニクスに関する研究
Semiconductor Spintronics

固体中のスピンと電荷の自由度を使った省エネルギかつ高機能なスピントロニクス素子の実現をめざして、半導体、磁性半導体、金属磁性体におけるスピン現象、及びそれらを利用した新規スピン機能材料、新規スピントロニクス素子の創生に関する研究を行っている。

We are working on spin-related phenomena in semiconductors, magnetic semiconductors, and magnetic metals as well as novel functional spin materials and devices, in order to realize low-power functional spintronic devices.

1) スピントロニクスに関する研究
Spintronics

分子線エピタキシやスパッタリング法を用いたスピントロニクス材料や構造の作製、スピン機能物性の評価と理解。

Development of functional spin materials and structures by using molecular beam epitaxy and sputtering, understanding and characterization of spin-related phenomena are being carried out.

2) 金属磁性体とその機能素子応用に関する研究
Magnetic metal functional devices and their application

20 nm 以下のスピントロニクス素子作製および素子加工技術の開発、作製した微細スピントロニクス素子の特性評価、そしてスピントロニクス素子を利用した種々の集積回路試作を進めている。

Development of spintronic devices with the size of less than 20 nm and their processing technology, characterization of the fabricated spintronic devices, and fabrication of various prototype integrated circuits employing spintronic devices are being carried out.

3) 磁性半導体及びその量子構造の物性と応用に関する研究
Properties and application of magnetic semiconductors and their quantum structures

強磁性体と半導体を組み合わせた新しい半導体デバイスの基礎的研究を行っている。

Exploration of novel spintronic semiconductor devices based on ferromagnet/semiconductor structures is being carried out.

4) 半導体量子構造における電子・光・スピン物性とその応用に関する研究
Characterization of electrical, optical, and spin properties of semiconductor quantum nanostructures and their applications

III-V 族化合物半導体超構造中におけるキャリアや原子核のスピンに注目し、フェムト秒オーダの磁化分解測定を行ってそのコヒーレンスを理解するとともに、量子情報処理等への応用を研究している。
Study of ultrafast processes, especially spin dynamics of carriers in III-V semiconductor nanostructures is being carried out by femto-second time resolved measurements to the application for such as ultrafast optical switches and quantum information processing.

2. ナノスピンデバイス・メモリの研究
Nano-spin device and memory

高機能・低消費電力のメモリ・デバイスとそれによって可能となる新しい論理集積回路および情報通信処理システムを、スピン・磁性を用いて実現することを目標として、スピンメモリ・ロジック実現に向けた基盤技術を開発する。
To realize high-performance low-power consumption spin memory and logic devices, we are developing technologies to realize advanced spin memory and logic devices using magnetic tunnel junctions (MTJs) consisting of ferromagnetic metal electrodes and insulating barriers.

1) 高出力トンネル磁気抵抗素子の開発
Magnetic tunnel junctions with high output voltage
面内・垂直磁気異方性トンネル磁気抵抗(TMR)素子の高出力化を行っている。
Development of high performance magnetic tunnel junctions (MTJs) consisting of ferromagnetic metal electrodes with in-plane or perpendicular magnetic easy axis and insulating barrier is being carried out.

2) 金属系スピントロニクスデバイスの開発
Metal-based spintronics devices
微細な金属系スピントロニクスデバイスの作製とその特性評価、スピンメモリ・ロジック基本回路試作を行っている。
Fabrication of metal-based spintronic devices with small dimension and characterization of their properties and making basic spintronics-based circuits experimentally are carried out.

3) スピン注入磁化反転素子の開発
Spin transfer torque memory and logic devices
低書き込み電力に向けたスピン注入磁化反転に関する研究を行っている。
Characterizing spin transfer torque switching toward reduction of writing power is being carried out.

3. 省エネルギー・スピントロニクス論理集積回路の研究開発
Research and Development of Ultra-low Power Spintronics-based VLSIs

日本学術振興会「最先端研究開発支援プログラム」「省エネルギー・スピントロニクス論理集積回路の研究開発」において、参画研究室と連携してスピントロニクス論理集積回路基盤技術に関する研究が行われた。
Technologies based on spintronics that makes VLSIs high performance and ultra low power were studied under "Research and Development of Ultra-low Power Spintronics-based VLSIs" program granted by JSPS through the FIRST program.

1) スピントロニクス材料に関する研究
Spintronics materials
スピントロニクス論理集積回路試作用の世界最高水準のデバイス材料に関する研究が行われた。
Advanced spintronics device materials for VLSI were studied.

2) スピントロニクスデバイスに関する研究
Spintonics devices
論理集積回路用スピントロニクスデバイスの高性能化に関する研究が行われた。
Spintronics devices with low write current, high thermal stability, high TMR and high reliability were studied.

3) 革新的スピントロニクス材料・デバイスに関する研究
New Spintronics materials and devices
電界効果型磁化制御・デバイス、半導体スピントロニクス材料・デバイス技術に関する研究が行われた。
Magnetic materials and devices for electic-field control, and semiconductor spintronic materials and devices were studied.

4) スピントロニクス論理集積回路に関する研究
Spintronics based logic circuits
専用ならびに汎用スピントロニクス論理集積回路向けアプリケーションの設計・原理検証に関する研究が行われた。
Design and verification of spintronics logic integrated circuits, and design for high-speed and stable operation of spintronics VLSI were studied.

4. 耐災害性に優れた安心・安全社会のためのスピントロニクス材料・デバイス基盤技術に関する研究
Research and Development of Spintronics Material and Device Science and Technology for a Disaster-Resistant Safe and Secure Society

文部科学省「次世代 IT 基盤構築のための研究開発」の委託研究である「耐災害性に優れた安心・安全社会のためのスピントロニクス材料・デバイス基盤記述開発」プロジェクトにおいて、プロジェクト参画研究室と連携して高機能スピントロニクスワーキングメモリ向け材料・デバイスの開発と大容量スピントロニクスワーキングメモリ向け材料・デバイスの開発が行われた。
High-speed spintronics working memory and high-density spintronics working memory were studied in "Research and Development of Spintronics Material and Device Science and Technology for a Disaster-Resistant Safe and Secure Society" program under Research and Development for Next- Generation Information Technology of MEXT.

1) 高速スピントロニクスワーキングメモリに関する研究
Developments of high-speed spintronics working memory
磁気トンネル接合を基本構造とする高速二端子スピントロニクス素子、及び高速三端子スピントロニクス素子を作製し、基礎特性を調べた。
High-speed two terminal and three terimanl devices based on magnetic tunnel junction were fabricated and studied.

2) 大容量ワーキングメモリに関する研究
Developments of high-density spintronics working memory
40 nmϕ以下の極微細なトンネル磁気接合を作製し、基礎特性を調べた。
Magnetic tunnel junctions with a diameter less than 40 nmϕ were fabricated and studied.

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8. H. Ohno, "Perpendicular CoFeB-MgO for Spintronics Devices ***(Half-Plenary)***," 19th International Conference on Magnetism (ICM2012), July 8-13, 2012.
9. M. Sawicki, D. Chiba, O. Proselkov, A. Korbecka, Y. Nishitani, F. Matsukura, J. A. Majewski, J. Sadowski, T. Dietl, and H. Ohno, "Experimental Probing of the Magnetic Order in Ultrathin (Ga,Mn)As ***(invited)***," 19th International Conference on Magnetism (ICM2012), July 8-13, 2012.
10. H. Ohno, "Ferromagnetism in Semiconductors ***(Plenary)***," 4th WUN International Conference on Spintronics (WUN-SPIN), July 23-25, 2012.

11. H. Ohno, "Bridging Semiconductor and Magnetism ***(Plenary)***," 31st International Conference on the Physics of Semiconductors (ICPS 2012), July 29-August 3, 2012.
12. H. Ohno, "Magnetic Semiconductors: Materials, Physics and Devices ***(Tutrial)***," 7th International Conference on Physics and Applications of Spin-related Phenomena in Semiconductors (PASPS-VII), August 5-8, 2012.
13. H. Ohno, "Magnetic Tunnel Junction: A Spintronic Nonvolatile Device for VLSI Applications ***(Plenary)***," 2012 IEEE Lester Eastman Conference on High Performance Devices, August 7-9, 2012.
14. H. Ohno, "Perpendicular CoFeB-MgO Mgnetic Tunnel Junction ***(invited)***," SPIE NanoScience + Engineering, August 12-16, 2012.
15. S. Ikeda, M. Yamanouchi, H. Sato, K. Miura, H. D. Gan, K. Mizunuma, S. Fukami, S. Kanai, F. Matsukura, N. Kasai, and H. Ohno, "Perpendicular CoFeB-MgO magnetic tunnel junction ***(invited)***," SPIE Nanoscience+Engineering 2012, August 12-16, 2012.
16. H. Ohno, "Spintronics Meets CMOS VLSI ***(invited)***," Samsung the Future Technology Seminar, August 28, 2012.
17. H. Ohno, "Magnetism for Nonvolatile Memories and Beyond ***(invited)***," Joint European Magnetic Symposia (JEMS 2012), September 9-14, 2012.
18. H. Ohno, "Electric-field manipulation and switching of magnets ***(invited)***," International Workshop on Spin Phenomena in Reduced Dimensions, September 19-21, 2012.
19. H. Ohno, "Physics and Materials of Perpendicular CoFeB-MgO Magnetic Tunnel Junction ***(invited)***," 21th International Colloquium on Magnetic Films and Surfaces (ICMFS), September 24-28, 2012.
20. H. Ohno, "Bridging Semiconductors and Magnetism – Toward Stand-by Power Free VLSIs ***(plenary)***," International Conference on Hot-Wire Chemical Vapor Depositon (HWCVD7), October 8-12, 2012.
21. H. Ohno, "Spintronics-based Nanovolatile CMOS VLSI ***(keynote)***," Advanced Metallization Conference 2012 (ADMETA), October 23-25, 2012.
22. M. Yamanouchi, "Spintronics devices for nonvolatile memory and logic ***(invited)***," 12th Non-Volatile Memory Technology Symposium (NVMTS), October 31-November 2, 2012.
23. H. Ohno, "Electric-field manipulation of magnetization ***(invited)***," Sweden-Japan Workshop on Quantum Nano-Physics and Electronics (QNANO2013), January 13-14, 2013.
24. H. Ohno, "Physics and Materials of Perpendicular CoFeB-MgO Magnetic Tunnel Junction ***(invited)***," Tohoku-Harvard Joint Workshop, January 15-16, 2013.
25. M. Yamanouchi , L. Chen, H. Sato, S. Fukami, S. Ikeda, F. Matsukura, and H. Ohno, "Three terminal switching devices based on an interconnection material Cu ***(invited)***," The 3rd CSIS International Symposium on Spintronics-based VLSIs and The 11th RIEC International Workshop on Spintronics, January 31-February 1, 2013.
26. H. Ohno, "Ferromagnetism in Semiconductors ***(Keynote)***," AIMR International Symposium 2013 (AMIS 2013), February 19-21, 2013.
27. H. Ohno, "Two and three terminal non-volatile spintronics devices for VLSI applications ***(invited)***," Spin-Orbit Torque Workshop (SOIT), February 24-27, 2013.
28. L. R. Fleet, K. Yoshida, H. Kobayashi, Y. Kaneko, S. Matsuzaka, Y. Ohno, H. Ohno, S. Honda, J. Inoue, and A. Hirohata, "Spin Injection Across Abrupt Fe/GaAs(001) Interfaces," International Magnetics Conference (INTERMAG), May 7-11, 2012.
29. H. Sato, M. Yamanouchi, K. Miura, S. Ikeda, R. Koizumi, F. Matsukura, and H. Ohno, "Thickness Dependence of Thermal Stability Factor in CoFeB/MgO Perpendicular Magnetic Tunnel Junctions," International Magnetics Conference (INTERMAG), May 7-11, 2012.

30. S. Ikeda, R. Koizumi, H. Sato, M. Yamanouchi, K. Miura, K. Mizunuma, H. Gan, F. Matsukura, and H. Ohno, "CoFeB Composition Dependence of Magnetic Anisotropy and Tunnel Magnetoresistance in CoFeB/MgO Stack Structures," International Magnetics Conference (INTERMAG), May 7-11, 2012.

31. L. Chen, F. Matsukura, C. P. Lin and H. Ohno, "Electrical Signal Related to Ferromagnetic Resonance in (Ga,Mn)As/p-GaAs Bilayer Structure," 9th RIEC International Workshop on Spintronics, May 31-June 2, 2012.

32. C. Zhang, J. Ishihara, M. Ono, Y. Ohno, and H. Ohno, "Coherent Control of Nuclear Spins in a (110) GaAs/GaAlAs Quantum Well by Nuclear Electric Resonance," 9th RIEC International Workshop on Spintronics, May 31-June 2, 2012.

33. Y. Kaneko, H. Kobayashi, S. Matsuzaka, S. Ikeda, L. Fleet and A. Hirohata, "Electrical and Optical Detection of Spin Polarized Electrons in n-GaAs/MgO/CoFe Junctions," 9th RIEC International Workshop on Spintronics, May 31-June 2, 2012.

34. S. Ishikawa, H. Sato, M. Yamanouchi, S. Ikeda, S. Fukami, F. Matsukura, and H. Ohno, "Magnetic Anisotropy of Co/Pt Based Electrodes for Magnetic Tunnel Junctions with Peerpendicular Magnetic Easy Axis," 9th RIEC International Workshop on Spintronics, May 31-June 2, 2012.

35. S. Fukami, M. Yamanouchi, T. Koyama, K. Ueda, Y. Yoshimura, K. J. Kim, D. Chiba, H. Honjo, N. Sakimura, R. Nebashi, Y. Kato, Y. Tsujii, A. Morioka, K. Kinoshita, S. Miura, T. Suzuki, H. Tanigawa, S. Ikeda, T. Sugibayashi, N. Kasai, T. Ono, and H. Ohno, "High-speed and Reliable Domain Wall Motion Device: Material Design for Embedded Memory and Logic Application," IEEE Symposium on VLSI Technology and Circuits, June 12-15, 2012.

36. S. Ishikawa, H. Sato, M. Yamanouchi, S. Ikeda, S. Fukami, F. Matsukura, and H. Ohno, "Magnetic properties in stack structures with Co/Pt multilayer," Annual Meeting of Strategic Japanese-German Joint Research Program "ASPIMATT": Advanced Spintronic Materials and Transport Phenomena, July 4-6, 2012.

37. L. Fleet, K. Yoshida, H. Kobayashi, Y. Knaeko, S. Matsuzaka, Y. Ohno, H. Ohno, S. Honda, J. Inoue, and A. Hirohata, "The Effect of An Inhomogeneous Interface on the Transport Properties Access Fe/GaAs(001) Films," 19th International Conference on Magnetism (ICM2012), July 8-13, 2012.

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40. S. Fukami, M. Yamanouchi, S. Ikeda, and H. Ohno, "Domain wall depinning probability - Experiment and Theory," 21th International Colloquium on Magnetic Films and Surfaces (ICMFS), September 24-28, 2012.

41. K. Mizunuma, M. Yamanouchi, H. Sato, S. Ikeda, S. Kanai, F. Matsukura, and H. Ohno, "Ferromagnetic resonance by means of homodyne detection technique in CoFeB/MgO magnetic tunnel junctions with perpendicular easy axis," 21th International Colloquium on Magnetic Films and Surfaces (ICMFS), September 24-28, 2012.

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44. S. Ishikawa, H. Sato, M. Yamanouchi, S. Ikeda, S. Fukami, F. Matsukura, and H. Ohno, "Magnetic properties of MgO-[Co/Pt] multilayer with a CoFeB insertion layer," 12th Joint Magnetism and Magnetic Materials/International Magnetics Conference, January 14-18, 2013.

45. H. Sato, M. Yamanouchi, S. Ikeda, S. Fukami, K. Mizunuma, F. Matsukura, and H. Ohno, "MgO/CoFeB/Ta/CoFeB/MgO recording structure in magnetic tunnel junctions with perpendicular magnetic easy axis," 12th Joint Magnetism and Magnetic Materials/International Magnetics Conference, January 14-18, 2013.

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48. J. Ishihara, Y. Ohno, and H. Ohno, "Anisotropic Spin Dephasing Dynamics of Quasi-one Dimensional Electron Gas in Modulation-doped GaAs/AlGaAs Wire," Tohoku-Harvard Joint Workshop, January 15-16, 2013.

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50. K. Mizunuma, M. Yamanouchi, H. Sato, S. Ikeda, S. Kanai, F. Matsukura, and H. Ohno, "Ferromagnetic Resonance Measurement in CoFeB-MgO Magnetic Tunnel Junctions with Perpendicular Magnetic Easy Axis," Tohoku-Harvard Joint Workshop, January 15-16, 2013.

51. S. Fukami, M. Yamanouchi, S. Ikeda and H. Ohno, "Depinning error rate of domain wall in Co/Ni nanowire," The 3rd CSIS International Symposium on Spintronics-based VLSIs and The 11th RIEC International Workshop on Spintronics, January 31-February 1, 2013.

52. S. Ishikawa, H. Sato, M. Yamanouchi, S. Ikeda, S. Fukami, F. Matsukura, and H. Ohno, "Magnetic tunnel junctions consisting of Co/Pt multilayer and a CoFeB insertion layer with high thermal stability," The 3rd CSIS International Symposium on Spintronics-based VLSIs and The 11th RIEC International Workshop on Spintronics, January 31-February 1, 2013.

53. K. Mizunuma, M. Yamanouchi, H. Sato, S. Ikeda, S. Kanai, F. Matsukura, and H. Ohno, "Measurement of magnetic properties in CoFeB-MgO p-MTJs by ferromagnetic resonance with homodyne detection technique," The 3rd CSIS International Symposium on Spintronics-based VLSIs and The 11th RIEC International Workshop on Spintronics, January 31-February 1, 2013.

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【国際会議発表】(連携研究)

1. T. Hanyu, "Nonvolatile Logic-in-Memory Architecture Using an MTJ/MOS-Hybrid Structure and Its Applications ***(invited)***," COOL Chips XV, April 20, 2012.

2. T. Endoh, "MTJ based nonvolatile SRAM and low power nonvolatile logic-in-memory architecture ***(invited)***," The 2012 International Meeting for Future of Electron Devices, Kansai (IMFEDK 2012), May 9, 2012.

3. T. Endoh, T. Ohsawa, S. Ikeda, T. Hanyu, N. Kasai, H. Ohno, "MTJ based nonvolatile SRAM and low power nonvolatile logic-in-memory architecture ***(invited)***," IEEE International

Magnetics Conference, May 7-11, 2012.

4. F. Matsukura, L. Chen, C. P. Lin, M. Yamanouchi, and H. Ohno, "Electromotive Force in (Ga,Mn)As-based Structures ***(invited)***," 9th RIEC International Workshop on Spintronics, May 31-June 2, 2012.
5. D. Chiba, K. Shimamura, M. Kawaguchi, S. Ono, S. Fukami, N. Ishiwata, K. Kobayashi, and T. Ono, "Electric field control of Curie temperature in ultra-thin Co films ***(invited)***," 9th RIEC International Workshop on Spintronics, May 31-June 2, 2012.
6. M. Hayashi, "Current driven domain wall motion in perpendicularly magnetized CoFeB nanostructures ***(invited)***," International symposium on the dynamics of domain walls 2012, June 1, 2012.
7. H. Naganuma, G. Kim, M. Oogane, Y. Ando, "Perpendicularly magnetized magnetic tunnel junctions using L10-ordered alloy ***(invited)***," BIT' s 1st Annual World Congress of Advanced Materials, June 8, 2012.
8. T. Hanyu, "Challenge of Nonvolatile Logic-in-Memory Architecture Towards Cool LSI Chips ***(invited)***," 2012 Spintronics Workshop on LSI, June 11, 2012.
9. T. Endoh, "Restructuring of Memory Hierarchy in Computing System with STT-MRAM Technologies ***(invited)***," 2012 Spintronics Workshop on LSI, June 11, 2012.
10. T. Endoh, T. Ohsawa, H. Koike, T. Hanyu, and H. Ohno, "Restructuring of memory hierarchy in computing system with spintronics-based technologies ***(invited)***," 2012 IEEE Symposium on VLSI Technology and Circuits, June 12-14, 2012.
11. T. Endoh, "Restructuring of Memory Hierarchy in System and No-Standby-Power Nonvolatile Logic with STT-MRAM Technology ***(invited)***," IMEC-Tohoku University Seminar, June 21, 2012.
12. D. Chiba, "Electric-field control of ferromagnetism in semiconductors and metals ***(invited)***," 2012 International School and Conference on the Physics of Semiconductors, June 14, 2012.
13. T. Endoh, "MTJ Based Non-volatile RAM and Low Power Non-volatile Logic Suitable to Pipeline Architecture ***(invited)***," 8th Annual SEMATECH Symposium Japan, June 26, 2012.
14. M. Hayashi, "Magnetization Dynamics in Perpendicularly Magnetized CoFeB Nanostructures ***(invited)***," International conference of young researchers on advanced materials, July 4, 2012.
15. T. Endoh, T. Ohsawa, T. Hanyu, and H. Ohno, "MTJ based nonvolatile logic for ultimate power management ***(invited)***," The 19th International Conference on Magnetism with Strongly Correlated Electron Systems (ICM2012 with SCES), July 9, 2012.
16. T. Ono, "Current-induced domain wall motion in perpendicularly magnetized nanowire ***(invited)***," The 19th International Conference on Magnetism with Strongly Correlated Electron Systems (ICM2012 with SCES), July 12, 2012.
17. T. Hanyu, "Prospects of Nonvolatile Logic-in-Memory Architecture Using Magnetic Tunnel Junction Devices ***(invited)***," CMOS Emerging Technologies 2012 Conference, July 18, 2012.
18. F. Matsukura, "Electromotive Forces Induced by Magnetization Dynamics in (Ga,Mn)As," ***(invited)***, 4th WUN International Conference on Spintronics (WUN-SPIN), July 23-25, 2012.
19. M. Hayashi, "Current induced effective fields in Ta|CoFeB|MgO heterostructures ***(invited)***," ICC-IMR/Reimei Miniworkshop on Spintronics, August 7, 2012.
20. T. Ono, "Current-induced domain wall motion in perpendicularly magnetized nanowires ***(invited)***," XXI International Materials Research Congress, August 14, 2012.
21. D. Chiba, "Electric field control of ferromagnetic properties in 3d-transition metal ultra-thin films ***(invited)***," The 21st International Colloquium on Magnetic Films and Surfaces (ICMFS), September 24-28, 2012.
22. T. Endoh, "MTJ Based Non-volatile RAM and Logic for Future System with Standby Power Zero ***(invited)***," 9th Sematech International Symposium on Advanced Gate Stack Technology,

October 4, 2012.

23. K. Kinoshita, "Process Module Developments for Spintronics Devices ***(invited)***," AVS 59th International Symposium & Exhibition, November 1, 2012.
24. T. Ono, "Physics and applications of current-induced domain wall motion in magnetic nanowires ***(invited)***," 6th International Workshop on Advanced Materials Science and Technology, November 1, 2012.
25. F. Matsukura, "Recent Progress in Spintronics Materials ***(invited)***," 8th International Workshop on LEEM/PEEM, November 11-15, 2012.
26. T. Endoh, "High Speed STT-MRAM for Cash Memory and Low Power Nonvolatile Logic with MTJ technology ***(invited)***," New Non-Volatile Memory Workshop, November 16, 2012.
27. T. Endoh, "Panel Discussion: Can emerging memories find their own niche and survive? ***(Panelist)***" New Non-Volatile Memory Workshop 2012, November 16, 2012.
28. F. Matsukura, "Magnetization reversal of CoFeB induced by the application of electric fields ***(invited)***," WPI-AIMR Workshop on Topological Functional Materials and Devices, November 30-December 1, 2012.
29. D. Chiba, "Electric field control of ferromagnetism in ultra-thin metals ***(invited)***," WPI-AIMR Workshop Topological Functional Materials and Devices, December 1, 2012.
30. T. Ono, "Physics and Applications of Current-Induced Domain Wall Motion in Magnetic Nano-wires ***(invited)***," 2012 Workshop on Innovative Nanoscale Devices and Systems (WINDS), December 4, 2012.
31. T. Endoh, T. Ohsawa, H. Koike,T. Hanyu, H. Sato, S. Ikeda, H. Ohno, "Tutorial: Spintronics for Embedded Non-volatile Electronics ***(invited)***," International Electron Devices Meeting (IEDM), December 8, 2012.
32. T. Ono, "Current-induced domain wall motion: Intrinsic pinning and two barrier stability ***(invited)***," Symposium on Surface and Nano Science, January 17, 2013.
33. M. Oogane, H. Saruyama, Y. Kurimoto, H. Naganuma, and Y. Ando, "Magnetic tunnel junctions using L10-ordered MnAl electrode ***(invited)***," The 3rd CSIS International Symposium on Spintronics-based VLSIs and The 11th RIEC International Workshop on Spintronics, January 31-February 1, 2013.
34. Y. Tsuji, R. Nebashi, N. Sakimura, A. Morioka, H. Honjo, K. Tokutome, S. Miura, T. Suzuki, S. Fukami, K. Kinoshita, T. Hanyu, T. Endoh, N. Kasai, H. Ohno, and T. Sugibayashi, "Spintronics Primitive Gate with High Error Correction Function ***(invited)***," The 3rd CSIS International Symposium on Spintronics-based VLSIs and The 11th RIEC International Workshop on Spintronics, January 31-February 1, 2013.
35. T. Hanyu, "Towards a New Paradigm LSI Based on Nonvolatile Logic-in-Memory Architecture ***(invited)***," The 3rd CSIS International Symposium on Spintronics-based VLSIs and The 11th RIEC InternationalWorkshop on Spintronics, January 31-February 1, 2013.
36. S. Matsunaga, S. Miura, H. Honjo, K. Kinoshita, S. Ikeda, T. Endoh, H. Ohno, and T. Hanyu, "Standby-Power-Free Fully Parallel TCAM Chip Based on Compact Nonvolatile Logic-in-Memory Cell Structure ***(invited)***," The 3rd CSIS International Symposium on Spintronics-based VLSIs and The 11th RIEC International Workshop on Spintronics, January 31-February 1, 2013.
37. M. Hayashi, "Current induced spin orbit torques in magnetic heterostructures ***(invited)***," International Workshop on Spin-Orbit Torque (SOIT), February 24-27, 2013.
38. M. Hayashi, "Vector measurements of the current induced effective fields in Ta|CoFeB|MgO heterostructures ***(invited)***," APS March Meeting, March 19, 2013.
39. M. Oogane, M. Hosoda, H. Saruyama, H. Naganuma, and Y. Ando, "L10-MnAl films with high perpendicular magnetic anisotropy and low magnetic damping," IEEE International Magnetics Conference, May 7-11, 2012.

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41. N. Sakimura, R. Nebashi, Y. Tsuji, H. Honjo, T. Sugibayashi, H. Koike, T. Ohsawa, S. Fukami, T. Hanyu,H. Ohno, T. Endoh, "High-Speed Simulator including Accurate MTJ Models for Spintronics Integrated Circuit Design," IEEE International Symposium on Circuits and Systems (ISCAS2012), May 22, 2012.

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46. M. Sihotang, S. Matsunaga, and T. Hanyu, "Fine-Grained Power-Gating Scheme of a Nonvolatile Logic-in-Memory Circuit for Low-PowerMotion-Vector Extraction," 10th IEEE International Newcas Conference (NEWCAS), June 20, 2012.

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53. D. Suzuki, M. Natsui, and T. Hanyu, "Area-Efficient LUT Circuit Design Based on Asymmetry of MTJ's Current Switching for a Nonvolatile FPGA," The 55th International Midwest Symposium on Circuits and systems (IEEE MWSCAS 2012), August 6, 2012.

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56. J. Kim, M. Hayashi, S. Fukami, T. Suzuki, M. Yamanouchi, J. Sinha, S. Mitani, and H. Ohno, "Current induced effective fields and domain wall motion in perpendicularly magnetized Ta|CoFeB|MgO nanowires," The 21st International Colloquium on Magnetic Films and Surfaces (ICMFS), September 25, 2012.
57. D. Suzuki, Y. Lin, M. Natsui, and T. Hanyu, "Design of Compact Nonvolatile Lookup-Table Circuit Using Three-Terminal Magnetic-Tunnel-Junction-Based Single-Ended Structure," Solid State Devices and Materials (SSDM 2012), September 26, 2012.
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B2 超ブロードバンド信号処理（尾辻泰一･末光哲也）
Ultra-Broadband Signal Processing (T.Otsuji and T.Suemitsu)

新原理ミリ波・テラヘルツ波帯集積電子デバイスの研究
Novel millimeter-wave and terahertz-wave integrated microelectronic devices

いまだ未踏の電磁波領域であるミリ波・テラヘルツ波（サブミリ波）帯の技術を開拓、実用化するために、本領域で動作する新しい電子デバイスおよび回路システムの創出と、

それらの情報通信・計測システムへの応用に関する研究開発を行っている。第一に、半導体ヘテロ接合構造に発現する二次元プラズモン共鳴という新しい動作原理に立脚した集積型のコヒーレントテラヘルツ電磁波発生・信号処理デバイスの研究開発を進めている。電子デバイス・光子デバイス双方の動作限界を同時に克服するブレークスルーとして注目している。第二に、サブ波長領域に局在した低次元プラズモンの分散特性を光電子的に制御することによって、高次の信号処理機能を果たす新たなテラヘルツ帯メタマテリアル・回路システムの創出に取り組んでいる。第三に、新材料：グラフェン（単層グラファイト）を用いた新原理テラヘルツレーザーならびに極限高速トランジスタの開発を推進している。さらに、これら世界最先端の超ブロードバンドデバイス・回路を応用して、超高速無線通信や安心･安全のための新たな計測技術の開発を進めている。

We are developing novel, integrated electron devices and circuit systems operating in the millimeter-wave and terahertz regions. One example is the frequency-tunable plasmon-resonant terahertz emitters, detectors, and modulators. Another example is unique electromagnetic metamaterial circuit systems based on optoelectronic dispersion control of low-dimensional plasmons. We are also pursuing graphene-based new materials to create new types of terahertz lasers and ultrafast transistors, breaking through the limit on conventional transistor/laser operation. By making full use of these world-leading device/circuit technologies, we are exploring future ultra-broadband wireless communication systems as well as spectroscopic/imaging systems for safety and security.

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B3 量子光情報工学（枝松圭一・小坂英男・三森康義）
Quantum-Optical Information Technology (K.Edamatsu, H.Kosaka and Y. Mitsumori)

1. 光子を用いた量子情報通信技術の開発
Quantum info-communication technology using photons

半導体や擬似位相整合非線形光学結晶を用いた量子もつれ光子の発生・検出方法を開発している。また、光子間の量子ゲート動作を目指し、導波路媒質における単一光子レベルでの光学非線形性について研究している。

We investigate the generation and detection technique of entangled photon pairs using semiconductor and quasi-phase-matched (QPM) nonlinear optical materials. Also investigated are the optical nonlinearities of waveguide media at a single-photon level, aiming at photonic quantum gate operation.

2. 量子中継のための量子メディア変換
Quantum state transfer for quantum repeaters

量子情報通信における通信距離を飛躍的に増大するための量子中継器の実現を目指した光子・電子スピン間の量子メディア変換を行う基礎デバイスの開発を行っている。
We investigate quantum media conversion from a photon to an electron spin for quantum repeaters to extend the transmission distance of quantum info-communication.

3. 半導体量子ドットを用いた量子情報通信
Semiconductor quantum dots for quantum info-communication

量子情報通信への応用を目指した、半導体量子ドットの光物性および量子光学的な性質を研究している。
We investigate the spectroscopic and quantum optical properties of semiconductor quantum dots in view of quantum info-communication technology.

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5.C　ナノ分子デバイス基盤技術関連
Nano-Molecular Devices

C1　ナノ分子デバイス（庭野道夫・木村康男）
Nano-Molecular Devices (M. Niwano and Y.Kimura)

C1　ナノ分子デバイス（庭野道夫・木村康男）
Nano-Molecular Devices(M. Niwano and Y.Kimura)

1. 有機分子デバイスの表面・界面のナノスケール解析・制御
   Nanometer-scale analysis and control of surfaces and interfaces of organic molecular devices

   有機デバイスの表面・界面での現象をナノスケールで解析し、その動作原理を解明することにより、それらを制御し、有機デバイスの特性を向上させるための研究を行っている。
   We have analyzed phenomena on surface and interface of organic devices and have elucidated the principle of their operation on a nanometer scale to improve their performance.

2. 半導体表面用いた生体機能解析
   Biodynamic analysis on a semiconductor surface

   Si や GaAs 半導体表面上において、細胞やたんぱく質、DNA などの生体物質を赤外吸収法を用いて高感度に検出し、生体機能の解析を行っている。
   We have sensitively detected biological materials such as cells, proteins, and DNA molecules on a semiconductor surface such as Si or GaAs and we have analyzed biodynamics

3. 高感度バイオセンシング・システムの研究開発
   Research and development of a high-sensitive bio-sensing system

   赤外分光法を用いて溶液中で標識を用いずに生体物質を高感度に観測するためのバイオセンシング・システムの開発を行っている。
   We have investigated development of a label-free bio-sensing system for high-sensitive detection of biological materials in a solution using infrared absorption spectroscopy.

4. 陽極酸化過程を用いたナノデバイスの開発研究
   Research and development of fabricating nanodevices using anodization processes

   トップダウンプロセスと陽極酸化過程を組み合わせることによるナノデバイスの作製に関する研究を行っている。
   We have investigated fabrication of nanodevices by using both top-down processes and anodization processes.

5. 色素増感太陽電池の開発研究
   Research and development of dye-sensitized solar cells

   陽極酸化等の電気化学的手法による作製したナノ構造の作製およびその応用を行っている。特に、陽極酸化により作製した TiO_2 ナノチューブの色素増感太陽電池(DSSC)へ応用について研究している。
   We have investigated fabrication and application of nanostructures using electrochemical processes such as anodization. Especially, we have applied TiO_2 nanotubes fabricated by anodization to dye-sensitized solar cells (DSSC).

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６－２　施設の利用状況（平成 24 年度）
６－３　ナノ・スピン工学研究会
　　国際シンポジウムプログラム

6－1 施設の代表的装置の概要

a-1) ナノ・スピン電子ビーム・リソグラフィ関連

■ ナノ・スピン電子描画システム　　日本電子 JBX-9300SA

●用途　ナノスケールのパターン描画

●性能　加速電圧: 100 kV
最小線幅: 20 nm
ウェハサイズ: 5mm 角～300mm φ

■ ナノ・スピン縮小投影露光システム　　ニコン NSR-2005i10C

●用途　縮小投影露光による微細レジストパターンの形成

●性能　露光光源: i 線
投影倍率: 1/5
ウェハサイズ: 33mm φ、2 インチ φ
レチクルサイズ: 6インチ角

■ マスクアライナー　　カールズス MJB4

●用途　集積回路試作用フォトレジストパターンの形成

●性能　基板サイズ 5 ㎜角から最大 4 インチ角
マスクサイズ 2 インチ角から 5 インチ角
紫外線露光照度 25mW/㎠
露光分解能 0.8 μm ライン／スペース(バキュームコンタクト時)

■ 走査型電子顕微鏡(SEM)　　日本電子 JSM7401-FT

●用途　薄膜表面極微細構造解析

●性能　・2次電子像分解能
加速電圧 15kV　: 1.0 nm 保証
1kV GB モード : 1.5 nm 保証
・像種
二次電子像、反射電子像、二次電子＋反射電子像、エネルギーフィルタ像
・倍率
LM モード : ×25～19,000、SEM モード : ×100～1,000,000
自動倍率補正機能、倍率瞬時切替機能、像回転補正機能付き
・加速電圧
LM、SEM モード : 0.5～30kV、GB モード : 0.1～4kV
・プローブ電流　10^{-13}～2×10^{-9} A

■ マスク電子ビーム描画装置システム　　日本電子 JBX-9000ZB(A)

●用途　電子ビームを用いたマスク作製及びウェーハへの直接描画

●性能　最大加速電圧:50 kV
ビーム電流密度:10 A/cm^2
図形精度:0.02 μm
最小寸法:0.1 μm
マスクサイズ: 2.5, 6 インチ φ
ウェハ径:2、3 インチ φ, 33m φ

■ プラズマアッシャー　　ヤマト科学

●用途　試料表面のクリーニングやアッシング

●性能　プラズマモード：DP/RIE
最大出力：1000W
ガス：酸素
カーブトレーサモード可

a-2) 化合物半導体プロセス装置関連

■ 化合物 MBE（VG）　　VG V80H

●用途　化合物半導体薄膜（GaAs/AlAs, InAs/GaSb）のエピタキシャル成長

●性能　・ウェハサイズ　2インチ（最大3インチ）　任意形状（In 半田付け）
2インチあるいは2インチウェハの1／4（In Free）
・蒸着源　成膜室1　Ga, In, Al ×2, As×2, Sb, Si, Be, (Te)
成膜室2　Ga, Al×2, As, Si

■ SiO_2 堆積用プラズマCVD装置　　日本真空

●用途　SiO_2 の成膜

●性能　・到達真空度：
反応室：3×10^{-7}Torr 以下。
準備室：2×10^{-6}Torr 以下
・基板加熱　最高 400℃
・反応ガス種　SiH_4、N_2O
・膜厚分布　2インチウェハ内で±4%以下

■ Si_3N_4 堆積用プラズマCVD装置　　日本真空

●用途　化合物半導体基板への絶縁膜（シリコン窒化膜）の形成

●性能　・処理能力
φ2インチ基板　1枚／バッチ
φ33 基板　1枚/バッチ
不定形試料には、基板用ホルダを変えることで対応
・基板加熱温度　反応室　最高 400℃
準備室　最高 300℃
・RF電力　発振周波数　13.56MHz
最高　200W
・導入ガス　SiH_4、NH_3、Ar、N_2、O_2

■ 絶縁膜用ドライエッチング装置（RIE）　　日本真空

●用途　化合物半導体ウェハー上のシリコン窒化膜、シリコン酸化膜のエッチング

●性能　ガス種　CF_4　O_2　H_2
到達圧力　1.3×10^{-5}Pa 以下。
プロセス圧力　0.67～13.3Pa　以下
基板冷却機構　-30℃～25℃
基板処理枚数　φ2 インチ基板×1 枚/バッチ

■ 多目的電子ビーム蒸着装置(n型蒸着器)　日本真空

●用途　化合物半導体にp型及びn型電極材料を電子ビーム・抵抗加熱で蒸着し、熱処理を行う。

●性能　・n 型金属蒸着用電子ビーム蒸着装置
　ウェハサイズ　不定形(最大2インチ)
　電子ビーム蒸着源数　1
　抵抗加熱蒸着源数　2
・p 型金属蒸着装置
　ウェハサイズ　不定形(最大2インチ)
　蒸着源数　3
・n/p 型用赤外線熱処理装置
　ウェハサイズ　不定形(最大2インチ)
　加熱温度　900℃±5℃以内
　雰囲気ガス　窒素、アルゴン、水素

■ イオン発生システム(ECR－RIE)　日本真空

●用途　Cl_2ガスを用いた化合物半導体等の異方性エッチング

●性能　・チャンバ構成　エッチング室、ロードロック室
・到達真空度　10^{-8}Torr 台
・動作圧力　10^{-3}～10^{-5}Torr
・基板サイズ　2インチ、及び不定形
・エッチング速度　～2000Å/min(GaAs)
・エッチング分布　2インチ基板内±10%以下
・基板冷却　基板ホルダー水冷式
・イオン源　ECRパケット型
・イオンエネルギー　200～1000V
・プロセスガス　Cl_2、Ar、O_2

■ 半導体パラメータアナライザ　ソニーテクトロニクス

●用途　半導体電子デバイス等の電気的特性の評価

●性能　・ソースモニタユニット数　6
・分解能　8mV　4fA
・最大電圧・電流　200V 100 mA
・カーブトレーサモード可

■高機能マイクロカー測定装置装置　ネオアーク

●用途　約2μmφの領域における面内および極 kerr 効果の測定

●性能　光源:半導体レーザ　波長 650 nm
レーザスポットサイズ:約2μmφ
最大印加磁場:1.0T
温度:1.5K-400K(室温以下は液体 He 使用)
ステージ空間分解能　1μm

■多機能薄膜材料評価 X 線回折装置(2 次元検出器付 XRD)　Bruker

●用途　強力 X 線源と 2 次元検出器を用いた高速な X 線回折測定

●性能　X 線源:Cu
検出器:シンチレーション検出器、2 次元検出器
試料ステージ:5 軸試料ステージ

■接触段差計 （Dektak150） アルバック

●用途　試料方面に形成された段差、上面形状、表面粗さなどの評価

●性能　試料サイズ：150 ㎜φ以下
高さ方向分解能：0.1nm（@6.55 μm range）

■マイクロプローブ式低温ホール効果測定装置 理工貿易

●用途　半導体材料・ヘテロ構造におけるキャリア移動度・キャリア密度の評価

●性能　測定方法：Van der Pauw 法
ステージ温度範囲：20K～400K
最大印加磁界強度：0.4T

a-3) シリコンプロセス装置関係

■ ナノヘテロ界面処理加工システム

●用途　Si-Ge-C 系半導体ナノヘテロ構造形成及びその界面処理などの加工を行う。

●性能　Si-Ge 系薄膜のエピタキシャル成長や不純物ドーピングが可能。
300-1100℃ での各種ガス雰囲気中での熱処理が可能。

■ ナノヘテロ分析システム

●用途　Si-Ge-C 系半導体ナノヘテロ構造の高精度分析を行う。

●性能　Si-Ge-C 系半導体ナノヘテロ構造の原子結合・歪状態（レーザラマン分光システム）、薄膜積層構造(分光エリプソメータ)、電気抵抗（4探針法抵抗率測定器）の評価分析が可能。

■ 半導体電気磁気複合特性測定システム HP 他組上システム

●用途　直流ホール効果測定用

●性能　磁場強度 6.9kOe（ギャップ 60mm 時）。クライオスタットにより試料台温度を 10K まで冷却可能。

■ 常圧 CVD 装置

●用途　熱 CVD 法により SiO_2、PSG、BSG の薄膜形成を行う。

●性能　200～400℃での熱 CVD 法 により、SiO_2、PSG、BSG を形成可能 （2チャンバー）。
バッチ内膜厚分布±5%以内。

■ 原子スケール評価分析システム（AFM/STM） オミクロン

●用途　半導体プロセスの原子スケール評価分析等用。

●性能　超高真空 STM、コンタクトモード AFM、ノンコンタクトモード AFM。
LEED、オージェ、XPS 等可能。試料通電加熱可能。
装置接続延長管付

■ Si 系 RIE

●用途　シリコン加工用ドライエッチング装置(アネルバ EMR510 特)
Si 基板上の Si 系半導体のエッチングを行う。
SiO_2 加工用ドライエッチング装置(アネルバ DEM-451 特)
Si 基板上の Si および SiO_2 のエッチングを行う。
メタル加工用ドライエッチング装置(アネルバ L-451DA-L)
Si 基板上の金属のエッチングを行う。

●性能　シリコン加工用ドライエッチング装置
Si 基板上の Si 系半導体のエッチングが可能(ECR 型)。最大 6 インチウェハ。試料皿にのる不定形ウェハ可能。補助磁場印加、RF バイアス印可可能。
導入ガス：Cl_2、$SiCl_4$、BCl_3、SF_6、O_2、H_2、N_2、Ar
SiO_2 加工用ドライエッチング装置
Si および Si 基板上の SiO_2 のエッチングが可能 (RF 励起平行平板型)。
導入ガス：CF_4、SF_6、O_2、H_2、N_2、Ar
メタル加工用ドライエッチング装置
Si 基板上の金属のエッチングが可能 (RF 励起平行平板型)。
エッチング室用ガス：N_2、Ar、H_2、BCl_3、$SiCl_4$、Cl_2、CF_4、SF_6、O_2
アッシング室用ガス：O_2、N_2

■ X 線光電子分光装置 (ESCA)

SSI SSX－100、Kratos AXIS-NOVA

●用途　SSI SSX-100 表面元素分析用
Kratos AXIS-NOVA 表面元素分析用、表面元素分布イメージング用

●性能　SSI SSX-100
単色化 X 線源(ALKα)
最少分析領域 150μm
最少パスエネルギー25eV
最高エネルギー分解能 0.58eV(Ag 3d 5/2)
Kratos AXIS-NOVA
単色化 X 線源(AlKα)
スペクトルモード：最少分析領域 15μm
最少パスエネルギー5eV
最高エネルギー分解能 0.48eV(Ag 3d 5/2)
イメージングモード：最高空間能 3μm

■ ワイドレンジナノ形状測定システム

島津製作所　FT-3500

●用途　表面ナノ形状測定用

●性能　レーザー顕微鏡部
408nm 紫外半導体レーザスキャン方式
最大光学ズーム倍率 6 倍
観察視野 21～560m　最高ピクセル分解能 21nm
プローブ顕微鏡部
AFM(コンタクト、ダイナミック、位相)モード
表面電位モード
電流モード
磁気力モード
最大走査範囲(水)30μm×30μm×(高さ)4μm
最高制御分解能(水平)0.45μm×(高さ)0.06μm

a-4) 配線プロセス関係

■ ナノ・スピンメタルスパッタリングシステム　アネルバ EVP-38877

●用途　半導体集積プロセスにおける配線用 Al/Ti 薄膜の成膜

●性能　ターゲット材 Al-Si(1%)、Ti
基板ホルダ 33ミリφ、2インチφ、4cm 角以下のカットウェハ等
処理枚数 33ミリφウェハ 25 枚/ロット
膜厚分布 φ200ミリ内±5%以内
到達真空度 3×10-6Pa(スパッタ室)

■ アナライザー　アジレント HP-4156C

●用途　トランジスタの電圧-電流特性等各種電子デバイスの電気特性の測定

●性能　高分解能電圧電流ソース・モニタ・ユニット(1fA/2μV-100mA/100V) ×4
電圧測定ユニット×2
電圧源ユニット×2

■ ボンダー　ウェストボンド 7476D

●用途　集積化チップとパッケージ間の信号線配線

●性能　ワイヤー Al、Au
最大倍率 60 倍の可変ズーム顕微鏡
始点・終点の超音波出力／発生時間の独立設定が可能
パッケージの加熱可能

■ マスクアライナー　カールズス MJB4

●用途　集積回路試作用フォトレジストパターンの形成

●性能　基板サイズ 5mm 角から最大 4 インチ角
マスクサイズ 2 インチ角から 5 インチ角
紫外線露光照度 25mW/cm^2
露光分解能 0.8μm ライン／スペース(バキュームコンタクト時)

■ スパッタ装置　アネルバ

●用途　高密度金属配線形成、金属電極形成、
シリサイド用高融点金属薄膜形成

●性能　φ4"カソード×3 基
最大搬送基板サイズ:φ4"
基板加熱:MAX350℃
到達真空度:3×10^{-6}Pa 以下

■ 熱処理炉　東京エレクトロン

●用途　ゲート酸化膜、フィールド酸化膜の形成、
SiO_2、PSG などの熱処理、イオン注入後の熱処理、
シンタリング、アロイング

●性能　O_2、N_2、Ar、H_2、H_2+O_2雰囲気中での熱処理が可能。
ヒータ加熱方式
600℃～1050℃:4体
200℃～800℃:2体

■ 金属蒸着装置

日本シード研究所 M95-0019

●用途　金属薄膜(アルミニウム)の蒸着(抵抗加熱型)

●性能　蒸着源ボート数:2
対応ウェハサイズ:33mmφ、2"、6"、8"
膜厚コントローラによる蒸着レートの制御が可能
基板回転機構付き

■ LSI テスタ

HP9494

●用途　アナログ及びディジタル LSI チップの動作測定・検証

●性能　HP9494A ミックスドシグナル LSI テストシステム
30MHz 12Bit 任意波形発生器
1MHz 16Bit ディジタイザ

■ CAD システム

セイコー電子 SX-9000

●用途　集積回路パターン作製用 CAD

●性能　・SX9000 による CAD パターン作製
・JEOL52 フォーマットへの CAD データコンバート機能

■ 表面ナノ加工装置

日本ビーコ

●用途　走査型プローブ顕微鏡の探針によるナノメートルスケールの加工機能及びマニピュレーション及び走査型プローブ顕微鏡による各種プローブ顕微鏡像の観察

●性能　最大試料サイズ:210 mm
ステージ可動範囲:180 mm × 150 mm
最大走査範囲:XY:80 μm、Z:9 μm
ナノマニピュレーション機能:スクラッチ、陽極酸化
プローブ顕微鏡:STM、AFM(コンタクト、タッピング、摩擦力、電流)、FEM、SPoM、SCM、MFM

■ 非接触段差・粗さ計測装置

レーザーテック

●用途　試料表面のマイクロメートルからナノメートルスケールの段差や粗さを非接触にて測定する

●性能　ピクセル数:2048 × 2048
階調:16 ビット
共焦点顕微鏡機能による高さ測定機能(測定精度(σ):0.02 μm)
ミラウ型干渉による微細形状計測機能(測定精度(σ):00007 μm)

■ イオンビーム加工解析装置(FIB-SEM)

SII-NT NVision40(A)

●用途　集束イオンビームによる微細加工と SEM 観察

●性能　Ga イオンビーム最大加速電圧:30kV
電子ビーム最大加速電圧:30kV
Ar イオンビーム最大加速電圧::1kV
堆積可能膜:Pt,C,SiO2
二次イオン質量分析器(SIMS)
エネルギー分散型 X 線分光器(EDS)
走査透過型電子顕微鏡(STEM)機能
TEM 試料作製用マニピュレータ
最大サンプルサイズ:3 インチφ

■ レーザー直接描画装置

ネオアーク

●用途　フォトリソグラフィ用レジストに直接描画する

●性能　レーザー光源波長:375nm
最少描画線幅:1μm
最大描画範囲:50 mm × 50 mm

■ ナノ立体加工装置(AFM)

エスアイアイ・ナノテクノロジー(株) SPA400

●用途　原子間力顕微鏡像の取得及びその解析

●性能　AFM(コンタクトモード)、DFM(ノンコンタクトモード・サイクリックコンタクトモード・フェーズモード)
最大試料サイズ:35 mmφ
走査範囲:20μm、150μm

6 － 2 施設の利用状況(平成24年度)

平成24年度 ナノ・スピン実験施設 利用登録状況

(平成25年3月31日まで)

ナノ・スピン実験施設

	研究室名	利用責任者	利用登録者名	人数
施設常駐研究室	大野研	池田正二	大野教授 松倉教授 池田准教授 山ノ内助教 (研究員) 陳 (D3)ｲﾉﾋﾞｵｴﾗｲ (研究支援員)森田 平田 岩沼 川戸 後藤 (D2)水沼 (D1)石原 金井 (M2)秋田 金子 (M1)張 石川 (B4)岡田 都澤 竹内 (研究留学生)林 張 (CSIS) 佐藤助教 深見助教 (共同研究員)大嶋 山本 (技術専門職員)五十嵐	28
	庭野研	木村康男 平野愛弓	庭野教授 木村准教授 青沼助教 (社会人DC)今井 (D3)馬 (D2)小島 桜井(D1)西川 但木 (M2)張 小山内 宮 (M1)飯野 戸邉 山下 (B4)高沖 中山 (研究員)室田(*B登録) 村上(*B登録) 南(*B登録) 平野准教授 (D3)大嶋 (M2)松本 手塚 (M1)茂住 奥田 (B4)石成 松村	28
	佐藤研	櫻庭政夫	佐藤教授 櫻庭准教授 (D4)川島 (M2)阿部 (M1)上野 (B4)久保田 (研究員)李	7
	中島研	小野美武	中島教授 小野美助教 (M1)辻 山田	4
	尾辻研	末光哲也	尾辻教授 末光准教授 (研究員)鷹林 (D1)吉田 (M1)小林 栗田 江藤 矢部 (B4)畠山 川崎	10
	枝松研	三森康義	枝松教授 小坂准教授 三森准教授	3
	共通部	岩見友里香	岩見技術職員 目黒研究員	2
連携研究室	新田研	好田 誠	好田准教授 (D2)塩貝 野中 大橋	4
	寒川研	久保田智広	久保田准教授 (D3)五十嵐 (M2)田村	3
	安藤研	大兼幹彦	大兼准教授 永沼助教 (技術職員)佐藤 (D3)KWIL Lutondo KHAN Mohammed(M2)ｲｸﾃｨｱﾙ 畠山 (M1)猿山 森廣	9
	遠藤研	大澤 隆	大澤教授 五十嵐技術職員 伊賀研究生 馬研究支援者 (研究支援員)東 小池 (D1)今本 佐々木 (M2)吉田	9
	羽生研	夏井雅典	羽生教授 夏井助教 (研究員)高子 玉越 (研究支援員)鈴木 松永	6
	末光研	吹留博一	吹留准教授 (D1)朴 (M1)舩窪 (研究支援員)鄭 (共同研究員)舘野	5
	高桑研(多)	小川修一	小川助教 (M2)尾白 楊 (B4)林 川田	5
	金子研	金子俊郎	金子教授 加藤助教 (D3)趙 (M2)村越 (M1)高橋 安彦	6
	佐橋研	三宅耕作	三宅助教	1
	北上研	菊池伸明	菊池助教 古田(D1)	2

合計 132

共通利用対応装置　利用時間

平成24年3月1日から平成25年2月28日まで

| 装置名（Aは共通利用対応・Pはプロジェクト対応） | A/P ナノ・スピン電子描画システム | A/P ナノ・スピン縮小投影露光システム | A 走査型電子線微鏡 SEM | A アッシングシステム | A プラズマアッシャー | A マスクアライナ | A リソグラフィー関連 | A 洗浄ベンチ（EB室） | A 測長 SEM | A マスク電子ビーム描画システム | A 自動塗布ベーク | A 自動洗浄装置 | A サブミクロンマスクアライメント（旧ズースコンタクトアライナ） | A 化合物 MBE | A SiO2堆積用プラズマCVD装置 | A Si3N4堆積用プラズマCVD装置 | A 多目的電子ビーム蒸着装置（n型蒸着器） | A 抵抗加熱蒸着装置（p型蒸着器） | A 赤外線熱処理炉（n型・p型） | A イオン発生システム（ECR RIE） | A 絶縁膜用ドライエッチング装置（RIE） | A 洗浄ベンチ（化合物室） | A 高機能マイクロカー測定装置 | A 多機能薄膜材料評価X線回折装置 | A 接触段差計 | A マイクロプローブ式低温ホール効果測定装置 | A 半導体パラメータアナライザ | A/P ナノ・スピン熱処理装置 | A/P レーザラマン分光 | A/P 分光エリプソ | A X線電子分光装置 | A ワイドレンジナノ形状測定システム | A 4探針抵抗率測定器 | A X線光電子分光装置（ESCA） | A 半導体電気磁気複合特性測定システム | A 減圧CVD装置 | A 常圧CVD装置 | A Si 加工ドライエッチング | A SiO2加工ドライエッチング | A メタル加工ドライエッチング | A 原子スケール評価分析システム（AFM/STM） | A 洗浄ベンチ（Si室） | A/P ナノ・スピンメタルスパッタリングシステム | A/P ボンダー | A マスクアライナI | A ナノ立体加工装置（AFM） | A スパッタ装置 | A 熱処理炉 | A 金属蒸着装置 | A 洗浄ベンチ（3FUCR） | A イオンビーム加工解析装置 | A レーザー直接描画装置 | A 表面ナノ加工装置 | A 非接触段差・粗さ計測装置 | A LSIテスタ | A CADシステム | 共通利用対応装置　利用時間　小計 | プロジェクト用・研究室持込装置利用時間小計 | 実験装置利用時間　合計 |
|---|---|---

プロジェクト対応装置・研究室持込装置利用時間

平成24年3月1日から平成25年2月28日まで

| 装置名 | プロジェクト対応装置 | | | | | | | | 研究室持込装置 | | | | | | | |

共通利用対応装置　保守時間

平成24年3月1日から平成25年2月28日まで

| 装置名（Aは共通利用対応、Pはプロジェクト対応） | A/P ナノ・スピン電子描画システム | A/P ナノ・スピン縮小投影露光システム | A 走査型電子顕微鏡SEM | A アッシングシステム | A プラズマアッシャー | A マスクアライナ | A リソグラフィー関連 | A 洗浄ベンチ（EB室） | A 測長SEM | A マスク電子ビーム描画システム | A 自動塗布ベーク | A 自動洗浄装置 | A サブミクロンマスクアライメント（旧ズースコンタクトアライナ） | A 化合物MBE | A SiO2堆積用プラズマCVD装置 | A SiN3N4堆積用プラズマCVD装置 | A 多目的電子ビーム蒸着装置（n型蒸着器） | A 抵抗加熱蒸着装置（p型蒸着器） | A 赤外線処理炉（n型・p型） | A イオン発生システム（ECR RIE） | A 絶縁膜用ドライエッチング装置（RIE） | A 洗浄ベンチ（化合物室） | A 高機能マイクロカー測定装置 | A 多機能薄膜材料評価X線回折装置 | A 接触段差計 | A マイクロプローブ式低温ホール効果測定装置 | A 半導体パラメータアナライザ | A/P ナノ・スピン熱処理装置 | A/P レーザラマン分光 | A/P 分光エリプソ | A X線電子分光装置 | A ワイドレンジナノ形状測定システム | A 4探針抵抗率測定器 | A X線光電子分光装置（ESCA） | A 半導体電気磁気複合特性測定システム | A 減圧CVD装置 | A 常圧CVD装置 | A Si加工ドライエッチング | A SiO2加工ドライエッチング | A メタル加工ドライエッチング | A 原子スケール評価分析システム（AFM/STM） | A 洗浄ベンチ（Si室） | A/P ナノ・スピンメタルスパッタリングシステム | A/P ボンダー | A マスクアライナー | A ナノ立体加工装置（AFM） | A スパッタ装置 | A 熱処理炉 | A 金属蒸着装置 | A 洗浄ベンチ（3FUCR） | A イオンビーム加工解析装置 | A レーザー直接描画装置 | A 表面ナノ加工装置 | A 非接触段差・粗さ計測装置 | A LSIテスタ | A CADシステム | 共通利用対応装置保守時間　小計 | プロジェクト用・研究室持込装置保守時間　小計 | 実験装置保守時間　合計 |
|---|---|---

プロジェクト対応装置・研究室持込み装置保守時間

平成24年3月1日から平成25年2月28日まで

| 装置名 | プロジェクト対応装置 | | | | | | | | 研究室持込装置 | | | | | | | |

６－３ ナノ･スピン工学研究会

２１世紀に求められる高度な情報通信の実現には、ナノテクノロジーに基づく材料デバイス技術からシステム構築までの総合科学が必要である。「ナノ・スピン実験施設」は、この情報通信を支える総合科学技術の中の、ナノテクノロジーに基づいた電子の電荷・スピンを駆使する基盤的材料デバイス技術の研究を総合的・集中的に推進することを目的に、本研究所附属研究施設として平成16年4月1日に設置された。本研究会は、この施設を中心に展開して得られた成果にもとづき、広くナノエレクトロニクス・スピントロニクスに関連した科学技術に関して十分論議することを目的としている。平成２４年度は、以下の講演会を実施した。

第57回　平成24年5月11日　15:00-16:00
「人工神経細胞ネットワークの構築のための要素技術の確立と今後の展開」
山本　英明（東京農工大学大学院工学研究院）

第58回　平成24年5月14日　15:00-16:00
「電気泳動粒子の帯電制御」
小川　賢（セイコーエプソン株式会社コア技術開発センター）

第59回　平成24年7月24日　10:30-12:00、7月31日 10:30-12:00、
8月2日 13:00-14:30
“Terahertz response of graphene: physics and prospective devices”
Prof.Dr. Fedir VASKO (Dept. Electrical Eng., University at Buffalo, USA)
“THz detectors based on heating of two-dimensional electron gas in disordered nitride heterostructures”
Prof. Dr. Vladimir MITIN (Dept. Electrical Eng., University at Buffalo, USA)

第60回　平成24年8月30日　13:30-15:00
“Roles of transition ions and oxygen vacancies in Zn0.95Co0.05O1-δ diluted magnetic oxides”
Prof. H. Chou (National Sun Yat-Sen University, Taiwan)

第61回　平成24年10月12日　13:30-15:00
“Recent progress in extremely scaled devices based on GaN, graphene and III-Vs”
Huili (Grace) Xing (Dept. of Electrical Engineering, University of Notre Dame, USA)

第62回　平成24年11月29日　14:00-15:00
“Racetrack Memory Based on Exchange Bias”
Prof. K O'Grady (University of York, U. K.)

第63回 平成24年12月17日　3:00-19:30、12月18日　9:00-16:00
「歪みと量子閉じ込め効果を考慮したモンテカルロ計算によるナノゲートInGaAs/InAs/InGaAsチャネルHEMTのDC・RF特性」
○遠藤聡（NICT/富士通研）・渡邊一世・笠松章史（NICT）・三村高志（富士通研/NICT）他8件
「$LiNbO_3$導波路を用いたチェレンコフ位相整合型テラヘルツ光源開発とその応用」
塩田和教・小野 茂・入澤昭好・今村元規（アドバンテスト）他10件

第64回　平成24年12月21日　15:00-16:30
「機能性圧電ポリマーを用いた水素センサフィルム」

今井裕司（仙台高等専門学校 助教）

第 65 回　平成 25 年 3 月 4 日　11:00-12:00
"Wide Bandgap Heterojunctions on Crystalline Silicon"
Prof. James C. Sturm (Princeton University)

第 66 回　平成 25 年 3 月 14 日　15:00-18:00
"Prospects of silicon ULSI"
Dr.Vladimir VYURKOV, RIEC Visiting Professor (Institute of Physics and Technology, RAS, Moscow, Russia)
"Some approaches to the solution of equations of mathematical physics"
Dr. lgor SEMENIKHIN, RIEC Visiting Associate Professor (Institute of Physics and Technology, RAS, Moscow, Russia)
"Transport in graphene:quantum,relativistic,and simple"
Dr. Dmitry SVINTSOV, RIEC Visiting Research Fellow (Institute of Physics and Technology, RAS, Moscow, Russia)

The 9th RIEC International Workshop on Spintronics

May 31 – June 2, 2012
Laboratory for Nanoelectronics and Spintronics
Research Institute of Electrical Communication (RIEC)
Tohoku University, Sendai, Japan

Venue

Conference Room, Laboratory for Nanoelectronics and Spintronics,
Research Institute of Electrical Communication (RIEC), Tohoku University
2-1-1, Katahira, Aoba-ku, Sendai 980-8577, Japan (Access)

Invited Speakers (confirmed)

David D. Awschalom (UCSB)
Irene D'Amico (York Univ.)
Andrew J. Ferguson (Univ. Cambridge)
Vincent Jeudy (Univ. Paris Sud)
Makoto Kohda (Tohoku Univ.)
Aurelien Manchon (KAUST)
Yoshio Miura (Tohoku Univ.)
Yoshichika Otani (Univ. Tokyo)
Hiroaki Sukegawa (NIMS)
Seigo Tarucha (Univ. Tokyo)
Dieter Weiss (Univ. Regensburg)
Daichi Chiba (Kyoto Univ.)
Tomasz Dietl (Polish Acad. Sci.)
Kohei M. Itoh (Keio Univ.)
Paul J. Kelly (Univ. Twente)
Sang Ho Lim (Korea Univ.)
Fumihiro Matsukura (Tohoku Univ.)
Yuzo Ohno (Univ. Tsukuba)
Hideo Sato (Tohoku Univ.)
Yoshishige Suzuki (Osaka Univ.)
Evgeny Tsymbal (Univ. Nebraska)
Jianhua Zhao (Chinese Acad. Sci.)

Program

The program has been modified on May 29 as follows:
Program Time-table (revised)
(PDF file: 67 kB)

Poster Presentations

A poster session will be held in the afternoon (15:00-17:00) on **June 1 (Friday)**
in the Room A401 of Laboratory for Nanoelectronics and Spintronics, RIEC.
The size of each poster board is **80 cm wide** and **160 cm high**.
Note that the poster session is extended to 120 min (15:00-17:00).

On-site Registration:

Please come to the registration desk in front of the Conference Room of Laboratory for Nanoelectronics and Spintronics, RIEC.
The registration fee for attending the Workshop is free.
(The registration via e-mail has been closed.)

Banquet:

The banquet will be held in the evening (17:30–19:30) on **June 1 (Friday)** in Trattoria e Bar "Caccinu" located on the B1F of Sendai Kokusai Hotel.
The banquet fee (5,000 JPY) must be paid by cash (only JPY is available) at the registration desk.

Organizing Committee

Kohei M. Itoh (Keio Univ.), Hiroshi Katayama-Yoshida (Osaka Univ.), Yasuo Ando, Gerrit E. W. Bauer, Fumihiro Matsukura, Junsaku Nitta, Hideo Ohno, Masafumi Shirai (Tohoku Univ.)

Local Committee

Makoto Kohda, Fumihiro Matsukura, Yoshio Miura, Masafumi Shirai, Michihiko Yamanouchi (Tohoku Univ.)

Secretariat

Noriko Sato
Research Institute of Electrical Communication (RIEC), Tohoku University
2-1-1, Katahira, Aoba-ku, Sendai 980-8577, Japan

Sponsored by

Laboratory for Nanoelectronics and Spintronics
Research Institute of Electrical Communication (RIEC), Tohoku University

In corporation with

Center for Spintronics Integrated Systems (CSIS), Tohoku University

The workshop is organized in close collaboration with
"4th International Workshop on Spin Caloritronics",
which will be held on June 2 - 5, 2012 at the Institute of Materials Research (IMR), Tohoku University.
For more details, please refer the following web site:
URL: http://www-lab.imr.tohoku.ac.jp/~spincaloritronics4/

The 1st RIEC International Symposium on Brain Functions and Brain Computer

and

JSPS Core-to-Core Program Joint Seminar

"Atomically Controlled Processing for Ultralarge Scale Integration"

Date: November 15 - 16, 2012

Place: Laboratory for Nanoelectronics and Spintronics, Research Institute of Electrical Communication, Tohoku University

Organizers:

Symposium Co-Chairs

Koji Nakajima, Tohoku Univ., Michio Niwano, Tohoku Univ.

Program Committee

Takahiro Hanyuu, Tohoku Univ., Shigeo Sato, Tohoku Univ., Ayumi Hirano, Tohoku Univ.

Organizing Committee

Shigeo Sato, Tohoku Univ., Ayumi Hirano, Tohoku Univ., Junichi Murota, Tohoku Univ.

Program

November 15 (Thursday)

13:30 - 13:35 Opening Remarks
M. Niwano, Tohoku Univ., Japan

--- Session 1 (Chair: M. Niwano) ---

13:35 - 14:20 Mechanisms of synaptic plasticity in the mammalian brain
T. Bliss, National Institute for Medical Research, UK

14:20 - 14:50 Towards input-specific photoinactivation of neuronal networks in the hippocampus
H. Kamiya, Hokkaido Univ., Japan

14:50 - 15:20 Artificial lipid bilayers in silicon chips as a model for neuronal cell membranes
A. Hirano-Iwata, Tohoku Univ., Japan

15:20 - 15:35 Coffee Break

--- Session 2 (Chair: A. Hirano-Iwata) ---

15:35 - 16:05 Surface engineering techniques for designing neuronal networks *in vitro*
H. Yamamoto[1], T. Tanii[2], S. Nakamura[1], [1]Tokyo Univ. of Agriculture and Technology, [2]Waseda Univ., Japan

16:05 - 16:35 Construction of a bi-hemispheric cerebellar neuronal network model with realistic climbing fiber input and its application to adaptive control of an unstable robot
R. Pinzon-Morales, Y. Hirata, Chubu Univ., Japan

16:35 - 17:05 Oscillatory correlates of cortical function in an attractor network model
P. Herman, M. Lundqvist, A. Lansner, Royal Institute of Technology, Sweden

November 16 (Friday)

--- Session 3 (Chair: T. Hanyu) ---

9:00 - 9:30 Artificial retina and its application in retinal physiology
T. Yagi, Osaka Univ., Japan

9:30 - 10:00 SpiNNaker: Low-Power Chips to Model a Billion Neurons
T. Sharp, S. Furber, The University of Manchester, UK

10:00 - 10:30 Neurochip using stochastic logic
S. Sato, K. Nakajima, Tohoku Univ., Japan

10:30 - 10:45 Coffee Break

--- Session 4 (Chair: S. Sato) ---

10:45 - 11:15 Logical Operations exploiting Stochastic Resonance for Coarse-Grained Devices
T. Asai, Hokkaido Univ., Japan

11:15 - 11:45 Some recent French projects in bio-inspired Systems-on-Chips
P. Garda, Pierre and Marie Curie Univ., France

11:45 - 11:50 Closing Remarks
K. Nakajima, Tohoku Univ., Japan



Workshop poster

Speakers

Kathy Aidala (Mount Holyoke College)
Robbie Berg (Wellesley College)
Tina Brower-Thomas (Howard University)
Yasuo Cho (Tohoku University)
David Clarke (Harvard University)
James Griffin (Howard Nanoscale Science and Engineering Facility)
Yoshiro Hirayama (Tohoku University)
Evelyn Hu (Harvard University)
Junsaku Nitta (Tohoku University)
Hideo Ohno (Tohoku University)
Taiichi Otsuji (Tohoku University)
Steven Richardson (Howard University)
Eiji Saitoh (Tohoku University)
Takashi Takahashi (Tohoku University)
Robert Westervelt (Harvard University)
Amir Yacoby (Harvard University)
Hiroshi Yamaguchi (NTT, Tohoku University)

♦ **Poster session**
15:30-17:30 on January 15, 2013.

♦ **Program**

♦ **Committee and Secretariat**
Committee: H. Ohno, R. Westervelt, M. Niwano, S. Sato, E. Saitoh, S. Souma, and F. Matsukura
Secretariat: N. Sato

♦ **Organizations**
Research Institute of Electrical Communication, Tohoku University
WPI-Advanced Institute for Materials Research, Tohoku University
in collaboration with
School of Engineering, Graduate School of Science, Institute for Materials Research,
Center for Spintronics Integrated Systems, and RIEC Cooperative Research Project Type S.

♦ **Sponsors**
RIEC, WPI-AIMR, Grants for Excellent Graduate Schools (ECEI & WPI-AIMR)

♦ **Access**

♦ **Conference Photo**

Tohoku – Harvard Joint Workshop

New Directions in Materials for Nanoelectronics, Spintronics and Photonics

(10th RIEC International Workshop on Spintronics)

January 15 (Tuesday) - 16 (Wednesday), 2013
Conference Room, Laboratory for Nanoelectronics and Spintronics, RIEC, Tohoku University

January 15 (Tuesday)		
8:00	Meet at hotel lobby	
8:15	Transfer	
8:30	Registration	
8:45		
9:00	Opening	
9:15	T-1	Westervelt
9:30		
9:45	T-2	Cho
10:00		
10:15	Break	
10:30		
10:45	T-3	Aidala
11:00		
11:15	T-4	Yamaguchi
11:30		
11:45	T-5	Clarke
12:00		
12:15	Lunch	
12:30		
12:45		
13:00		
13:15		
13:30		
13:45		
14:00	T-6	Saitoh
14:15		
14:30	T-7	Hu
14:45		
15:00	T-8	Nitta
15:15		
15:30	Poster session Room A401	
15:45		
16:00		
16:15		
16:30		
16:45		
17:00		
17:15		
17:30	Transfer	
17:45		
18:00	Banquet	
18:15		
18:30		
18:45		
19:00		
19:15		
19:30		
19:45		

January 16 (Wednesday)		
8:00		
8:15		
8:30		
8:45		
9:00	W-1	Richardson
9:15		
9:30	W-2	Hirayama
9:45		
10:00	Break	
10:15		
10:30	W-3	Brower-Thomas
10:45		
11:00	W-4	Otsuji
11:15		
11:30	W-5	Griffin
11:45		
12:00	Lunch	
12:15		
12:30		
12:45		
13:00		
13:15		
13:30		
13:45	W-6	Yacoby
14:00		
14:15	W-7	Takahashi
14:30		
14:45	W-8	Berg
15:00		
15:15	W-9	Ohno
15:30		
15:45	closing	
16:00	Lab. tour	
16:15		
16:30		
16:45		













The 3rd CSIS International Symposium on Spintronics-based VLSIs

and

The 11th RIEC International Workshop on Spintronics

Date: January 31 and February 1, 2013

Venue: Laboratory for Nanoelectronics and Spintronics,
4th Floor, Conference Room, Tohoku University,
Sendai, Japan

http://www.csis.tohoku.ac.jp/

Symposium Registration

Registration:	E-mail to CSIS Support Office (sien@csis.tohoku.ac.jp) by January 25th, 2013.
Symposium Fee:	Free

Banquet Registration

Advance Registration:	E-mail to CSIS Support Office (sien@csis.tohoku.ac.jp) by January 15th, 2013.
Banquet Fee:	5,000 JPY Banquet Fee will be collected on site at the Symposium

Sponsors

The symposium and the workshop are sponsored and supported by:

- Cabinet Office, Government of Japan
- Ministry of Education, Culture, Sports, Science & Technology, Japan
- Japan Society for the Promotion of Science (JSPS) through the "Funding Program for World-Leading Innovative R&D on Science and Technology (the FIRST Program)"
- Research Institute of Electrical Communication (RIEC), Tohoku University
  in cooperation with Nation-wide Cooperative Research Projects

Organizers

Hideo Ohno (CSIS and RIEC, Tohoku University)
Tetsuo Endoh (CSIS and Graduate School of Engineering, Department of Electrical Engineering, Tohoku University)
Naoki Kasai (CSIS, Tohoku University)
Takahiro Hanyu (CSIS and RIEC, Tohoku University)
Yasuo Ando (CSIS and Graduate School of Engineering, Tohoku University)
Shoji Ikeda (CSIS and RIEC, Tohoku University)
Michihiko Yamanouchi (CSIS and RIEC, Tohoku University)
Hideo Sato (CSIS, Tohoku University)

Local Staff

Yutaka Kadowaki (CSIS, Tohoku University)
Noriko Sato (CSIS, Tohoku University)
Yuko Jidai (CSIS, Tohoku University)
Manami Abe (CSIS, Tohoku University)
Osamu Sugasawa (CSIS, Tohoku University)

PROGRAM

Thursday January 31, 2013 - Materials and Devices -		
Opening 9:00 -9:10		**Opening remarks** Hideo Ohno (Tohoku University)
Invited talk 9:10-9:45	T1	**Spin Torque MRAM using Perpendicular Magnetic Anisotropy** Daniel C. Worledge[1], D. W. Abraham[1], S. Brown[1], M. Gajek[1], M. C. Gaidis[1], G. Hu[1], K. Kita[1,2], J. Nowak[1], E. J. O'Sullivan[1], R. P. Robertazzi[1], J. Z. Sun[1], P. L. Trouilloud[1], and W. J. Gallagher[1] ([1]IBM, [2]The University of Tokyo)
Invited talk 9:45-10:20	T2	**Write Error Rate in STT-MRAM** Zihui Wang, Yuchen Zhou, Jing Zhang, Kimi Satoh, Jung Dong Ha and Yiming Huai (Avalanche Technology)
10:20-10:40		Coffee Break
Invited talk 10:40-11:15	T3	**Challenges of STT-MRAM for High Density Memory** Gwan-Hyeob Koh (Samsung Electronics)
Invited talk 11:15-11:40	T4	**Magnetic tunnel junctions using $L1_0$ ordered MnAl electrode** Mikihiko Oogane, H. Saruyama, Y. Kurimoto, H. Naganuma and Y. Ando (Tohoku University)
Invited talk 11:40-12:05	T5	**Junction size dependence of intrinsic critical current and thermal stability of MgO/CoFeB/Ta/CoFeB/MgO recording structure** Hideo Sato, M. Yamanouchi, S. Ikeda, S. Fukami, F. Matsukura, and H. Ohno (Tohoku University)
12:05-14:00		Lunch
Invited talk 14:00-14:35	T6	**Comparison between static and dynamic measurements of the spin Hall effect** Yoshichika Otani[1,2], K. Kondou[2], Y. Niimi[1], S. Kasai[3], H. Sukegawa[3], and S. Mitani[3] ([1]The University of Tokyo, [2]Riken-ASI, [3]NIMS)
Invited talk 14:35-15:10	T7	**Spin transfer torques in magnetic bilayers with strong spin orbit coupling** P. M. Haney[1], H.-W. Lee[2], K.-Jin Lee[3, 4, 1, 5], A.Manchon[6], and Mark D. Stiles[1] ([1]National Institute of Standards and Technology, [2]Pohang University of Science and Technology, [3]Korea University, [4]Korea Institute of Science and Technology, [5]University of Maryland, [6]King Abdullah University of Science and Technology)
Invited talk 15:10-15:35	T8	**Current induced torques in magnetic heterostructures** Masamitsu Hayashi[1], J. Kim[1], M. Yamanouchi[2], S. Fukami[2], T. Suzuki[3], J. Sinha[1], S. Mitani[1], and H. Ohno[2] ([1]National Institute for Materials Science, [2]Tohoku University, [3]Renesas Electronics Corporation)

15:35-15:55	Coffee Break	
Invited talk 15:55-16:20	T9	**Three terminal switching devices based on an interconnection material Cu** Michihiko Yamanouchi , L. Chen, H. Sato, S. Fukami, S. Ikeda, F. Matsukura, and H. Ohno (Tohoku University)
Invited talk 16:20-16:45	T10	**Electric Field-induced Magnetization Switching in CoFeB** Fumihiro Matsukura[1], S. Kanai[1], M. Yamanouchi[1], S. Ikeda[1], Y. Nakatani[2], and H. Ohno[1] ([1]Tohoku University, [2]University of Electro-communications)
Invited talk 16:45-17:20	T11	**First Principles Study on the Gilbert Damping Constants of Transition Metal Alloys** Akimasa Sakuma (Tohoku University)
17:20-17:30	Coffee Break	
17:30-19:00	**POSTER SESSION** See pages 5 and 6	
Banquet 19:30-21:00	CACCINU (Italian restaurant), Sendai Kokusai Hotel*, B1 * http://www.tobu-skh.co.jp/english/index.html	

Friday February 1, 2013 Spintronics-based LSIs		
Invited talk 9:00-9:35	F1	**Recent Progress in ST-MRAM at Everspin Technologies** Jon M. Slaughter, T. Andre, S. Alam, N.D. Rizzo, J. Janesky, R. Whig, F.B. Mancoff, D. Houssameddine, M. L. Schneider, H. -J. Chia, J. J. Sun, S. Aggarwal, K. Nagel, S. Deshpande, B.N. Engel, M. DeHerrera and P. LoPresti (Everspin Technologies)
Invited talk 9:35-10:10	F2	**STT-MRAM for Mobile SOC: Embedding Nonvolatile RAM in Application Processors** Seung H. Kang (Qualcomm Technologies)
Invited talk 10:10-10:45	F3	**High Speed STT-MRAM for Cash Memory and Low Power Nonvolatile Logic with MTJ technology** Tetsuo Endoh (Tohoku University)
10:45-11:05		Coffee Break
Invited talk 11:05-11:30	F4	**Standby-Power-Free Fully Parallel TCAM Chip Based on Compact Nonvolatile Logic-in-Memory Cell Structure** Shoun Matsunaga[1], S. Miura[2], H. Honjo[2], K. Kinoshita[1], S. Ikeda[1], T. Endoh[1], H. Ohno[1], and T. Hanyu[1]([1]Tohoku University, [2]NEC Corporation)
Invited talk 11:30-11:55	F5	**Spintronics Primitive Gate with High Error Correction Function** Yukihide Tsuji[1], R. Nebashi[1], N. Sakimura[1], A. Morioka[1], H. Honjo[1], K. Tokutome[1], S. Miura[1], T. Suzuki[2], S. Fukami[3], K. Kinoshita[3], T. Hanyu[3], T. Endoh[3], N. Kasai[3], H. Ohno[3], and T. Sugibayashi[1] ([1]NEC Corporation, [2]Renesas Electronics Corporation, [3]Tohoku University)
Invited talk 11:55-12:30	F6	**MRAM-based Look Up Table for radiation hardened FPGA** O.Gonçalves, Guillaume Prenat and B.Dieny (Spintec)
12:30-14:30		Lunch
Invited talk 14:30-15:05	F7	**Prospects and Challenges of Magnetic Domain-Wall Racetrack Memory for High-Density Storage** Weisheng S. Zhao[1, 2], N. Ben Romdhane[1,2], Y. Zhang[1,2], J-O Klein[1, 2], C. Chappert[1, 2], R. Mantovan[3], A. Lamperti[3], R.P. Cowburn[4], T. Trypiniotis[4], M. Klaui[5], J. Heinen[5], B. Ocker[6], D. Ravelosona[1, 2] ([1]University of Paris Sud, [2]CNRS, [3]Laboratorio MDM IMM CNR, [4]Univ Cambridge, [5]Johannes Gutenberg Univ Mainz, [6]Singulus Technologies)
Invited talk 15:05-15:40	F8	**Brain Like Computing Based on the Physics of Nano Devices and Materials** Tadashi Shibata (The University of Tokyo)
Invited talk 15:40-16:15	F9	**Towards a New Paradigm LSI Based on Nonvolatile Logic-in-Memory Architecture** Takahiro Hanyu (Tohoku University)
Closing 16:15-16:20		**Closing remarks**

Thursday January 31, 2013

POSTER SESSION 17:30-19:00

P01	**Temperature Dependence of Spin Polarization in Co/Ni Nanowires with Different Co and Ni Thicknesses Determined by Domain Wall Dynamics** K. Ueda[1], R. Hiramatsu[1], D. Chiba[1,2], S. Fukami[3], M. Yamanouchi[3], H. Ohno[3], Y. Nakatani[4] and T. Ono[1] ([1]Kyoto University, [2]Japan Science and Technology Agency, [3]Tohoku University, [4]University of Electro-Communications)
P02	**High-speed Simulator Including Accurate MTJ Models for Spintronics Integrated Circuit Design** N. Sakimura[1], H. Koike[2], R. Nebashi[1], Y. Tsuji[1], A. Morioka[1], H. Honjo[1], S. Fukami[2], T. Ohsawa[2], T. Hanyu[2], H. Ohno[2], T. Sugibayashi[1] and T. Endoh[2] ([1]NEC Corporation, [2]Tohoku University)
P03	**Spin Seebeck Thermoelectric Generators** A . B . Cahaya[1], G.E.W Bauer[2]and O.A Tretiakov[1] ([1]Tohoku University, [2]Delft University of Technology)
P04	**Effects of Sputtering Deposition Process on Perpendicular Magnetic Anisotropy of [Co/Pt] Multilayers** C. Yoshida, Y. Yamazaki, Y. Iba, T. Takenaga and T. Sugii (Low-power Electronics Association & Project)
P05	**Spin torque transistor revisited** T. Chiba[1], G.E. W. Bauer[1,2], Saburo Takahashi[1] ([1]Tohoku University, [2]Delft University of Technology)
P06	**Nonvolatile Look-up Table Circuit Using Three-Terminal MTJ-Based Logic-in-Memory Structure** D. Suzuki and T. Hanyu (Tohoku University)
P07	**The effects of deposition rate and annealing on CoFeB/MgO/CoFeB perpendicular magnetic tunnel junctions** Lin-Xiu Ye, Ching-Ming Lee, Hau-Kang Chen, Te-ho Wu (National Yunlin University of Science and Technology)
P08	**The role of B and Co in the perpendicular magnetic anisotropy of CoFeB/MgO interface: a first principles study** M. Tsujikawa, Y. Miura and M. Shirai (Tohoku University)
P09	**Design of Low-Energy Nonvolatile TCAM Using Logic-in-Memory Architecture** S. Matsunaga[1], and T. Hanyu (Tohoku University)
P10	**Perpendicular magnetic properties and magnetic damping constant of thin CoFeB films** M. Oogane, M. Kubota, H. Naganuma, and Y. Ando (Tohoku University)
P11	**Spin torque diode effect in magnetic tunnel junction using L1o-ordered free layer** H. Naganuma, K. Hatakeyama, G. Kim, Y. Kawada, M. N. I. Khan, N. Inami, M. Oogane, Y. Ando (Tohoku University)
P12	**Bias voltage dependence of spin torque diode effect in CoFeB/MgO/CoFeB magnetic tunnel junction** Tian Yu, H. Naganuma, N. Inami, M. Oogane, Yasuo Ando (Tohoku University)

P13	**Dependence of perpendicular magnetic anisotropy of $L1_0$-FePd/CoFeB films on post-deposition annealing temperature** M. N. I. Khan, H. Naganuma, M. Oogane and Y. Ando (Tohoku University)
P14	**Depinning error rate of domain wall in Co/Ni nanowire** S. Fukami, M. Yamanouchi, S. Ikeda and H. Ohno (Tohoku University)
P15	**A New Sensing Scheme with High Signal Margin Suitable for Spin-Transfer Torque RAM** H. Koike, T. Ohsawa and T. Endoh (Tohoku University)
P16	**600MHz Nonvolatile Latch Based on a New MTJ/CMOS Hybrid Circuit Concept** T. Endoh[1], S. Togashi[1], F. Iga[1], Y. Yoshida[1], T. Ohsawa[1], H. Koike[1], S. Fukami[1], S. Ikeda[1], N. Kasai[1], N. Sakimura[1, 2], T. Hanyu[1], and H. Ohno[1] ([1]Tohoku University, [2]NEC Corporation)
P17	**A Fine-Grained Power Gating Architecture for MTJ-based Embedded Memories** T. Ohsawa[1], H. Kioke[1], S. Miura[1, 2] ,H. Honjo[1, 2], K. Tokutome[1, 2], S. Ikeda[1], T. Hanyu[1], H. Ohno[1], and T. Endoh[1] ([1]Tohoku University, [2]NEC Corporation)
P18	**Two-Step Writing Method for STT-MTJ to Improve Switching Probability and Write Speed** F. Iga, Y. Suzuki, T. Ohsawa, S. Ikeda, T. Hanyu, H. Ohno, and T. Endoh (Tohoku University)
P19	**Magnetic tunnel junctions consisting of Co/Pt multilayer and a CoFeB insertion layer with high thermal stability** S. Ishikawa, H. Sato, M. Yamanouchi, S. Ikeda, S. Fukami, F. Matsukura, and H. Ohno (Tohoku University)
P20	**Electrical detection of ferromagnetic resonance in (Ga,Mn)As** L. Chen, F. Matsukura and H. Ohno (Tohoku University)
P21	**Measurement of magnetic properties in CoFeB-MgO p-MTJs by ferromagnetic resonance with homodyne detection technique** K. Mizunuma, M. Yamanouchi, H. Sato, S. Ikeda, S. Kanai, F. Matsukura, and H. Ohno (Tohoku University)
P22	**Magnetic Field Angle Dependence of the Probabilities of Electric-Field Induced Magnetization Switching** S. Kanai[1], M. Yamanouchi[1], S. Ikeda[1], Y. Nakatani[2], F. Matsukura[1], and H. Ohno[1] ([1]Tohoku University, [2]University of Electro-communications)



RIEC
Research Institute of Electrical Communication
Tohoku University

The Joint Symposium of 7th International Symposium on Medical, Bio- and Nano-Electronics, 4th International Workshop on Nanostructures & Nanoelectronics, and JSPS Core-to-Core Program Joint Seminar "Atomically Controlled Processing for Ultralarge Scale Integration"

March 7-8, 2013

Research Institute of Electrical Communication
Tohoku University

Co-sponsored by

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Site: Laboratory for Nanoelectronics and Spintronics,
Research Institute of Electrical Communication,
Tohoku University

Organizer:

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Program

March 7 (Thursday)

Room: 4F, Room A401, *Laboratory for Nanoelectronics and Spintronics*

13:00~13:05 Opening Remarks
Michio Niwano (Tohoku University, Japan)

(Chair: Yasuo Kimura)

13:05 ~13:50 TiO_2 nanotubes (and similar): An overview and update on recent advancements and applications
Patrik Schmuki (University of Erlangen Nuremberg, Germany)

13:50~14:10 Diverse Applications of Nanostructured Silicon
Nobuyoshi Koshida (Tokyo University of Agriculture and Technology, Japan)

14:10~14:30 In situ observation of N719 dye on TiO_2 in dye-sensitized solar cells
Fumihiko Hirose (Yamagata University, Japan)

14:30~14:45 Coffee break

(Chair: Masashi Sahashi)

14:45~15:05 Biomedical Application of Phase-Change Nano-Droplets
Kenichi Kawabata (Central Research Laboratory, Hitachi, Ltd., Japan)

15:05~15:35 Magnetic "Lab-on-a-chip"
B. Sinha, J.I. Lim, S.J. Oh, S.Y. Yoo, K.W. Kim, A. Mohamed, and CheolGi Kim (Center for NanoBio Engineering & SpinTronics, Chungnam National University, Korea)

15:35~15:55 Study on medical-bio application of spin torque oscillator
Masashi Sahashi[1], Kousaku Miyake[1], Yohei Shiokawa[1], Yoshihito Okutomi[1], Yuki Kozono[1], Tetsuya Nakamura[1], Hiroshi Tsukahara[2], and Hiroshi Imamura[2]
([1]Tohoku University, Japan, [2]National Institute of Advanced Industrial Science and Technology (AIST), Japan)

15:55~16:25 Magnetic thin films with perpendicular magnetic anisotropy for magnetic tunnel junctions
Young Keun Kim, Do Kyun Kim, Ki Ha Kim (Department of Materials Science and Engineering, Korea University, Korea)

16:25~16:40 Coffee break

(Chair: Masao Sakuraba)

16:40~17:10 Nanotechnology Research and Innovation at Albany NanoTech Complex - On Worldwide Collaboration for Research and Fabrication -
Makoto Hirayama (College of Nanoscale Science and Engineering, State University of New York, USA)

17:10~17:30 DLTS Evaluation of GeNX/Ge Structures Fabricated by ECR-Plasma Techniques
H. Okamoto[1], H. Narita[1], T. Iwasaki[1], T. Ono[1], Y. Fukuda[2], Y. Otani[2], H. Toyota[3], M. Sakuraba[4], J. Murota[4] and M. Niwano[4] ([1]Hirosaki University, Japan, [2]Tokyo University of Science, Suwa, Japan, [3]Hiroshima Institute of Technology, Japan, [4]Tohoku University, Japan)

March 8 (Friday)

Room: 4F, Conference Room, *Laboratory for Nanoelectronics and Spintronics*

(Chair: Ko-ichiro Miyamoto)

9:00~ 9:20 Fabrication and structure modulation of high-aspect-ratio porous GaAs through anisotropic chemical etching, anodic etching, and anodic oxidation
Sachiko Ono, Shunsuke Kotaka, and Hidetaka Asoh (Kogakuin University, Japan)

9:20~9:40 Graphene on Sapphire and its Application to Biosubstrates
Toshio Ogino and Kenji Yamazaki (Yokohama National University, Japan)

9:40~10:00 Plasmonic Metal Nanostructures for Photoelectrochemical Applications
Tetsu Tatsuma (University of Tokyo, Japan)

10:00~10:20 Electrochemical deposition of gold nanoparticles on TiO_2 surfaces
Yasuo Kimura (Tohoku University, Japan)

10:20~10:35 Coffee break

(Chair: Tatsuo Yoshinobu)

10:35~10:55 Micropatterned neuronal network in culture as a model system of CNS local circuit
Hideaki Yamamoto[1], Takashi Tanii[2], Shun Nakamura[1] ([1]Tokyo University of Agriculture and Technology, Japan, [2]Waseda University, Japan)

10:55~11:25 Chip-based (bio-)chemical sensors for biopolymer testing and bioprocess monitoring
M. Bäcker[1,2], S. Schusser[1,2], M. Leinhos[1,2], A. Poghossian[1,2], P. Wagner[3], M. J. Schöning[1,2] ([1]Institute of Nano- and Biotechnologies (INB), FH Aachen, Germany, [2]Peter Grünberg Institute (PGI-8), Forschungszentrum Jülich GmbH, Germany, [3]Institute for Materials Research (IMO), Hasselt University, Belgium)

11:25~13:00 Lunch

13:00~14:30 Poster session

(Chair: Toshiro Kaneko)

14:30~14:50 Gas-Liquid Interfacial Plasmas for Gene Transfer System
Toshiro Kaneko, Shota Sasaki, Hideaki Konishi, Makoto Kanzaki, and Toshiaki Kato (Tohoku University, Japan)

14:50~15:20 Optical Fiber Based Plasma Endoscopes for Bio-Medical Applications
Sung-O Kim (Center for Optical Materials Science and Engineering Technologies (COMSET), Clemson University, USA)

15:20~15:50 Cold atmospheric plasma for biomedical applications
Tetsuji Shimizu[1], Georg Isbary[2], Julia L. Zimmermann[1], Wilhelm Stolz[2], Gregor E. Morfill[1] ([1]Max-Planck Institute for extraterrestrial physics, Germany, [2]Department of Dermatology, Allergology and Environmental Medicine, Hospital Munich Schwabing, Germany)

15:50~16:10 Bubble Cloud Generation in Tissue Mimicking Gel by Second-harmonic Superimposed Ultrasound
S. Yoshizawa[1], J. Yasuda[1], A. Asai[1] and S. Umemura[2] ([1]Department of Electrical and Communication Engineering, Tohoku University, Japan, [2]Department of Biomedical Engineering, Tohoku University, Japan)

16:10~16:25 Coffee break

(Chair: Masao Sakuraba)

16:25~16:55 Silicon-Germanium-Tin buffer layers through Pulsed Laser Induced Epitaxy
Stefano Chiussi, Stefan Stefanov, Jorge Carlos Conde, Julia Serra and Pío González (Dpto. Física Aplicada, E.E.I., Univ. de Vigo, Spain)

16:55~17:25 Group-IV-based molecular beam heteroepitaxy for optoelectronic device applications
Joerg Schulze, Inga Fischer, Martin Gollhofer, Daniel Haehnel, Mathias Kaschel, Michael Oehme, Filipe Oliveira and Marc Schmid (Institute for Semiconductor Engineering (IHT), University of Stuttgart, Germany)

17:25~17:30 Closing remarks
Masashi Sahashi (Tohoku University, Japan)

Poster Presentations

[P1] The role of correlated inhibitory firing
I. Sakurai,S. Kubota, and M. Niwano

[P2] Development of Organic Hydrogen Gas Sensor with Piezoelectric Poly(vinylidene fluoride) Film
Y. Imai, D. Tadaki, S. Iino, T. Nakayama, Y. Kimura, M. Niwano

[P3] Effect of Slow Cooling on Characteristics of OFETs using P3HT
S. Iino, D. Tadaki, T. Ma, J. Zhang, Y. Kimura, M. Niwano

[P4] Self-Organized Anodic Nanochannel Oxide Architectures: Growth in Glycerol/Phosphate Electrolyte and Example of Applications
K. Lee and P. Schmuki

[P5] Effect of Hydrogen Treatment on Characteristics of Titanium Oxide Nanotube Micro Hydrogen Gas Sensor
T. Tobe, R. Kojima, Y. Kimura and M. Niwano

[P6] Bilayer Reconstitution of Human *ether-a-go-go* Related Gene Channels using a Microfabricated Silicon Chip
A. Oshima, A. Hirano-Iwata, Y. Ishinari, Y. Kimura and M. Niwano

[P7] Viscoelastic Properties of Artificial Skin Estimated from Micro-displacement Induced by Acoustic Radiation Force
R. Nagaoka, K. Kobayashi,Y. Saijo

[P8] Development of Two-dimensional Blood Velocity Estimation Method and its Validation by Phase Contrast Magnetic Resonance Angiography
T. Kojima, A. Ohmori, H. Nakajima, T. Kameyama and Y. Saijo

[P9] Measurement and Analysis of Propagation of Myocardial Contraction Caused by Electrical Stimulation Using Myocardium of Rat
Y. Fujita, H. Tagashira, H. Hasegawa, K. Fukunaga, H. Kanai

[P10] Measurement of Shear Modules of Phantom Mimicking Soft Tissue Using Acoustic Radiation Pressure Generated by Continuous Wave Ultrasound
K. Tachi, H. Hasegawa, H. Kanai

[P11] Cavitation Generation Region Subjected to Nonlinear Pressure Field by Second-harmonic Superimposed Ultrasound
J. Yasuda, A. Asai, S. Yoshizawa and S. Umemura

[P12] In-plane Angular Dependence of Magnetic Property Originated from (1-102) Plane of Cr_2O_3
Y. Sato, N. Shimomura, T. Ashida, T. Nozaki, and M. Sahashi

[P13] Electron Conduction Scheme at Nano-Sized Contact in NCMR Device with Conductive-AFM
Y. Shiokawa, K. Kishi, H. Watanabe, M. Sahashi

[P14] Deposition of Wurtzite ZnO Thin Films on Co_3 Pt Buffer Layers by MBE Method toward Realization of ZnO based MTJs

M. Belmoubarik, T. Nozaki, H. Endo and M. Sahashi

[P15] Investigation of Pt/Co Nano-Contacts with AlOx Nano-Oxide Layer

M. Al-Mahdawi, M. Sahashi

[P16] Interface Effect on Perpendicular Magnetic Anisotropy of Co_3Pt

M. Oida, T. Ashida, T. Nozaki, and M. Sahashi

[P17] Composition Dependence of Low-Temperature Excess Heat Capacity in Oxide Glass

K. Nakamura, Y. Takahashi, R. Ihara, T. Fujiwara

[P18] Thermoelectric Properties of B and Sb co-doped Mg_2Si

M. Kubouchi, K. Hayashi, Y. Miyazaki

[P19] High-frame-rate pH Imaging of Liquid Flow in a Microchannel

A. Itabashi, K. Miyamoto, T. Wagner and T. Yoshinobu

[P20] Measurement of Small pH Changes by a Semiconductor-based Chemical Sensor

A. Sakamoto, K.Miyamoto, T. Wagner and T. Yoshinobu

[P21] Modeling and Simulation of the Light-Addressable Potentiometric Sensor for High-Resolution and High-Speed Chemical Imaging

Y. Guo, T. Wagner, K. Miyamoto and T. Yoshinobu