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Abstracts of Express Letters

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The Interface between Single Crystalline (001) $LaAlO_3$ and (001) Silicon

Dmitri O. Klenov*, Darrell G. Schlom[1], Hao Li[2] and Susanne Stemmer**
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Atomic resolution high-angle annular dark-field imaging in scanning transmission electron microscopy is used to determine atomic arrangements at $LaAlO_3$/Si interfaces, which were obtained by growing Si films epitaxially on (001) $LaAlO_3$ single crystals. An unusual 3 × 1 interface reconstruction, in which every third La column is removed from the interface plane, is observed. The interface atomic structure is discussed in the context of electrically favorable interfacial bonding between the ionic oxide and Si. [DOI : 10.1143/JJAP.44.L617]

Keywords: high-angle annular dark-field imaging, high-*k* gate dielectrics, oxide/semiconductor interfaces, scanning transmission electron microscopy

Materials Department, University of California, Santa Barbara, CA 93106-5050, U.S.A.
1 Department of Materials Science and Engineering, Pennsylvania State University, University Park, PA 16802-5005, U.S.A.
2 Microelectronics and Physical Sciences Laboratory, Motorola, 2100 E. Elliot Rd., Tempe, AZ 85284, U.S.A.
* E-mail address: d.o.klenov@physics.org
** E-mail address: stemmer@mrl.ucsb.edu

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Single-Photon Generation in the 1.55-μm Optical-Fiber Band from an InAs/InP Quantum Dot

Toshiyuki Miyazawa[1,*], Kazuya Takemoto[2], Yoshiki Sakuma[3], Shinichi Hirose[2], Tatsuya Usuki[2], Naoki Yokoyama[2], Motomu Takatsu[1] and Yasuhiko Arakawa[1,4,5]
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We first succeeded in generating single-photon pulses in the C-band (1.55-μm band: the highest transmittance in optical telecommunication bands) from a single InAs/InP quantum dot. The quantum dot with 1546.1-nm exciton emission was prepared by controlling the growth conditions. A well-designed mesa structure presented efficient injection of the emitted photons into a single-mode optical fiber. A Hanbury-Brown and Twiss measurement has proved that the photons through the fiber were single photons. We also performed to transmit single-photon pulses through 30-km optical fiber. This preliminary trial is a milestone toward quantum telecommunication using ideal single photons.
[DOI : 10.1143/JJAP.44.L620]

Keywords: InAs/InP, single quantum dots, single-photon pulses, C-band

1 Institute of Industrial Science, The University of Tokyo, 4-6-1 Komaba, Meguro-ku, Tokyo 153-8505, Japan
2 Fujitsu Laboratories Ltd., 10-1 Morinosato-Wakamiya, Atsugi, Kanagawa 243-0197, Japan
3 National Institute for Materials Science, 1-1 Namiki, Tsukuba, Ibaraki 305-0044, Japan
4 Nanoelectronics Collaborative Research Center, The University of Tokyo, 4-6-1 Komaba, Meguro-ku, Tokyo 153-8505, Japan
5 Research Center for Advanced Science and Technology, The University of Tokyo, 4-6-1 Komaba, Meguro-ku, Tokyo 153-8505, Japan
* E-mail address: miyatosi@iis.u-tokyo.ac.jp

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Blue Light-Emitting Diode Based on ZnO

Atsushi Tsukazaki[1], Masashi Kubota[2], Akira Ohtomo[1], Takeyoshi Onuma[2,3], Keita Ohtani[4], Hideo Ohno[4], Shigefusa F. Chichibu[2,3] and Masashi Kawasaki[1]*,**
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A near-band-edge bluish electroluminescence (EL) band centered at around 440 nm was observed from ZnO *p*–*i*–*n* homojunction diodes through a semi-transparent electrode deposited on the *p*-type ZnO top layer. The EL peak energy coincided with the photoluminescence peak energy of an equivalent *p*-type ZnO layer, indicating that the electron injection from the *n*-type layer to the *p*-type layer dominates the current, giving rise to the radiative recombination in the *p*-type layer. The imbalance in charge injection is considered to originate from the lower majority carrier concentration in the *p*-type layer, which is one or two orders of magnitude lower than that in the *n*-type one. The current-voltage characteristics showed the presence of series resistance of several hundreds ohms, corresponding to the current spread resistance within the bottom *n*-type ZnO. The employment of conducting ZnO substrates may solve the latter problem. [DOI : 10.1143/JJAP.44.L643]

Keywords: ZnO, light-emitting diode, thin film, pulsed laser deposition, self-absorption

1 Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan
2 Institute of Applied Physics and Graduate School of Pure and Applied Sciences, University of Tsukuba, Tsukuba, Ibaraki 305-8573, Japan
3 NICP, ERATO, Japan Science and Technology Agency, Kawaguchi, Saitama 332-0012, Japan
4 Laboratory for Nanoelectronics and Spintronics, Research Institute of Electrical Communication, Tohoku University, Sendai 980-8577, Japan
* Also at Combinatorial Material Science and Technology (COMET), Tsukuba, Ibaraki 305-0044, Japan.
** E-mail address: kawasaki@imr.tohoku.ac.jp

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DC and RF Characteristics in Al_2O_3/Si_3N_4 Insulated-Gate AlGaN/GaN Heterostructure Field-Effect Transistors

Narihiko Maeda*, Takashi Makimura, Takashi Maruyama[1], Chengxin Wang, Masanobu Hiroki, Haruki Yokoyama, Toshiki Makimoto[2], Takashi Kobayashi and Takatomo Enoki
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Al_2O_3/Si_3N_4 insulated-gate AlGaN/GaN heterostructure field-effect transistors (HFETs) have been fabricated, where excellent RF characteristics have been obtained in addition to the low gate leakage current as the result of employing the metal–insulator–semiconductor (MIS) structure. In an HFET with a gate length (L_g) of 0.1 μm, the cutoff frequency (f_T) and maximum oscillation frequency (f_{max}) were estimated to be 70 and 90 GHz, respectively. The drain current density (I_d) and transconductance (g_m) were 1.30 A/mm and 293 mS/mm, respectively. The gate leakage current (I_g) was as low as 4×10^{-5} A/mm even at a forward bias voltage of +3 V. [DOI : 10.1143/JJAP.44.L646]

Keywords: AlGaN, GaN, HFET, Al_2O_3, Si_3N_4, insulated-gate, metal-insulator-semiconductor (MIS), gate leakage current, cutoff frequency (f_T), maximum oscillation frequency (f_{max})

NTT Photonics Laboratories, NTT Corporation, 3-1 Morinosato Wakamiya, Atsugi, Kanagawa 243-0198, Japan
1 NTT Advanced Technology Corporation, 3-1 Morinosato Wakamiya, Atsugi, Kanagawa 243-0198, Japan
2 NTT Basic Research Laboratories, NTT Corporation, 3-1 Morinosato Wakamiya, Atsugi, Kanagawa 243-0198, Japan
* E-mail address: narihiko@aecl.ntt.co.jp

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Strongly Enhanced Phosphor Efficiency in GaInN White Light-Emitting Diodes Using Remote Phosphor Configuration and Diffuse Reflector Cup

Jong Kyu Kim[1], Hong Luo[2], Eric Fred Schubert[1,2]*, Jaehee Cho[3], Cheolsoo Sone[3] and Yongjo Park[3]
(Received April 1, 2005; accepted April 21, 2005; published May 11, 2005)

Enhancement of phosphor efficiency is reported for GaInN-based white light-emitting diodes (LEDs) employing a large separation between the primary LED emitter and the wavelength converter, and a diffuse reflector cup. Ray-tracing simulations show that extraction efficiency of wavelength-converted light is enhanced by 75%. The experimental improvement in phosphor efficiency of blue-pumped yellow phosphor is 15.4% compared with conventional phosphor-based white LEDs. The improvement is attributed to reduced re-absorption of wavelength-converted light by the LED chip. [DOI : 10.1143/JJAP.44.L649]

Keywords: light-emitting diodes, GaN, diffuse reflector, encapsulant, phosphor

1 Department of Electrical, Computer, and Systems Engineering, Rensselaer Polytechnic Institute, Troy, NY 12180, U.S.A.
2 Department of Physics, Applied Physics, and Astronomy, Rensselaer Polytechnic Institute, Troy, NY 12180, U.S.A.
3 Photonics Program Team, Samsung Advanced Institute of Technology, Suwon 440-600, Korea
* E-mail address: EFSchubert@rpi.edu

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Tunable Sub-Terahertz Wave Generation from an Organic DAST Crystal

Tetsuo Taniuchi*, Satoshi Ikeda, Shuji Okada[1] and Hachiro Nakanishi
(Received March 29, 2005; accepted April 22, 2005; published May 11, 2005)

Tunable sub-terahertz (THz) waves ranging from 0.3 to 3 THz were generated in a 4′-*N*,*N*-dimethylamino-*N*′-methyl-4-stilbazolium tosylate (DAST) crystal using the difference frequency mixing technique. We developed a dual-wavelength optical parametric oscillator near 990 nm with two $KTiOPO_4$ crystals as the input light source. The maximum output energy of 17 nJ/pulse (peak power: 1.4 W) was achieved at 0.7 THz using a high-quality DAST crystal with a 2-mm thickness.
[DOI : 10.1143/JJAP.44.L652]

Keywords: nonlinear optics, terahertz generation, optical parametric oscillator, difference frequency generation, organic crystal

Institute of Multidisciplinary Research for Advanced Materials, Tohoku University, 2-1-1 Katahira, Aoba-ku, Sendai 980-8577, Japan
1 Faculty of Engineering, Yamagata University, 4-3-16 Jonan, Yonezawa, Yamagata 992-8510, Japan
* E-mail address: taniuchi@tagen.tohoku.ac.jp

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Progress in the Efficiency of Wide-Gap $Cu(In_{1-x}Ga_x)Se_2$ Solar Cells Using CIGSe Layers Grown in Water Vapor

Shogo Ishizuka*, Keiichiro Sakurai, Akimasa Yamada, Hajime Shibata, Koji Matsubara, Minoru Yonemura[1], Satoshi Nakamura[1], Hisayuki Nakanishi[1], Takeshi Kojima and Shigeru Niki
(Received April 25, 2005; accepted May 5, 2005; published May 23, 2005)

Progress in the performance of wide-gap $Cu(In_{1-x}Ga_x)Se_2$ (CIGSe) solar cells for x values around 0.5 has been demonstrated using CIGSe layers grown in the presence of water vapor. While CIGSe thin films deposited in the presence of water vapor showed variations in electrical properties such as increases in hole carrier density and a consequent enhancement of *p*-type conductivity, no significant changes in the morphology and growth orientation were observed. Both the open circuit voltages and current densities of the CIGSe solar cells were improved using CIGSe layers grown in water vapor. An 18.1%-efficient cell with an open circuit voltage of 0.744 V, a current density of 32.4 mA/cm^2 and a fill factor of 0.752 was fabricated from a 1.3 eV-CIGSe (x ~ 0.48) layer.
[DOI : 10.1143/JJAP.44.L679]

Keywords: $Cu(In,Ga)Se_2$, thin-film solar cells, MBE, wide-gap, water vapor

National Institute of Advanced Industrial Science and Technology (AIST), 1-1-1 Umezono, Tsukuba, Ibaraki 305-8568, Japan
1 Tokyo University of Science, 2641 Yamazaki, Noda, Chiba 278-8510, Japan
* Corresponding author. E-mail address: shogo-ishizuka@aist.go.jp

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Incubation-Free Growth of Polycrystalline Si Films by Plasma-Enhanced Chemical Vapor Deposition Using Pulsed Discharge under Near Atmospheric Pressure

Hirotatsu Kitabatake[1], Maki Suemitsu[1], Hiroya Kitahata[2], Setsuo Nakajima[2], Tsuyoshi Uehara[2] and Yasutake Toyoshima[1,3]
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By using the plasma-enhanced chemical vapor deposition (PE-CVD) under near-atmospheric pressures, we have achieved a high rate growth, 1 nm/s, of polycrystalline Si films on glass substrates without incubation layers for the first time. We have employed a short-pulse based system for a stable operation of discharge at atmospheric pressures without inert gas dilution. This feature enabled us to employ an extremely high dilution of monosilane by hydrogen, which should be the origin of the incubation-free growth of our films, in addition to the basic advantage for the high rate growth inherent in atmospheric reaction systems. The films are mainly consisted of polycrystalline Si with grain size ranging from 5 nm to above 10 nm, as observed by Raman scattering, X-ray diffractions and cross sectional transmission electron microscopy. [DOI : 10.1143/JJAP.44.L683]
Keywords: plasma-enhanced chemical vapor deposition (PE-CVD), atmospheric pressure, pulsed discharge, polycrystalline Si, Raman scattering, X-ray diffraction (XRD), cross-sectional transmission electron microscopy (X-TEM), incubation layer

1 Center for Interdisciplinary Research, Tohoku University, Sendai 980-8578, Japan
2 Sekisui Chemicals Co., Ltd., Wadai, Tsukuba, Ibaraki 300-4292, Japan
3 Energy Technology Research Institute, National Institute of Advanced Industrial Science and Technology, Tsukuba, Ibaraki 305-8568, Japan

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Welding of Transparent Materials Using Femtosecond Laser Pulses

Takayuki Tamaki*, Wataru Watanabe, Junji Nishii[1] and Kazuyoshi Itoh
(Received February 22, 2005; accepted April 14, 2005; published May 23, 2005)

We report on laser welding between transparent materials without the insertion of intermediate layers such as glue by use of near-infrared femtosecond laser pulses. When femtosecond laser pulses are focused at the interface of transparent materials, the material around the focal point is melted and resolidified because of the temperature increases due to the localized nonlinear absorption of optical pulse energy. We experimentally succeeded in laser welding between two pieces of silica glass without the insertion of an intermediate layer by femtosecond laser pulses. This technique has a possible application to the joining of semiconductors such as silicon crystals. [DOI : 10.1143/JJAP.44.L687]
Keywords: laser welding, femtosecond laser, filament, fluorescence, silica glass, space selective

Department of Material and Life Science, Graduate School of Engineering, Osaka University, 2-1 Yamadaoka, Suita, Osaka 565-0871, Japan
1 Photonics Research Institute, Kansai Center, National Institute of Advanced Industrial Science and Technology, 1-8-31 Midorigaoka, Ikeda, Osaka 563-8577, Japan
* E-mail address: tamaki@photonics.mls.eng.osaka-u.ac.jp

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Synthesis of Pt-Entrapped Titanate Nanotubes

Atsushi Nakahira, Takashi Kubo, Yuki Yamasaki[1], Toshiyuki Suzuki[2] and Yuichi Ikuhara[3]
(Received April 21, 2005; accepted May 1, 2005; published May 23, 2005)

In this study, Pt-entrapped titanate nanotubes with approximately 10 to 15 nm in outer diameter and 5 nm in inner diameter and several hundreds in length were synthesized by a hydrothermal treatment of titanium oxide as a source material and a subsequent heat-treatment of the mixture of these titanate nanotube and a Pt salt. According to TEM observations, Pt nanocrystals with a few nm in diameter and 5 to 10 nm in length were contained in titanate nanotubes. These Pt nanocrystal-entrapped titanate nanotubes had the high photocatalytic properties, which are also expected to be a useful material for nanotechnology applications. [DOI : 10.1143/JJAP.44.L690]

Keywords: nanotube, Pt, nanocrystal, titanate, HTiO

Department of Materials Science, Osaka Prefecture University, 1-1 Gakuencho, Sakai, Osaka 599-8531, Japan
1 Department of Industrial Chemistry, Osaka Prefectural College of Technology, Saiwai-cho, Neyagawa, Osaka 572-8572, Japan
2 JFCC, Japan Fine Ceramics Center, 2-4-1 Mutsuno, Atsuta-ku, Nagoya 456-8587, Japan
3 The University of Tokyo, 2-11-16 Yayoi, Bunkyo-ku, Tokyo 113-8656, Japan

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High-Rate Growth of Films of Dense, Aligned Double-Walled Carbon Nanotubes Using Microwave Plasma-Enhanced Chemical Vapor Deposition

Mineo Hiramatsu, Hidetoshi Nagao[1], Masaki Taniguchi[1], Hiroshi Amano[1], Yoshinori Ando[1] and Masaru Hori[2]
(Received April 18, 2005; accepted April 27, 2005; published May 23, 2005)

Carbon nanotube (CNT) films were grown using microwave plasma-enhanced chemical vapor deposition. Catalytic cobalt (Co) nanoparticles were deposited on a silicon substrate using pulsed arc deposition. A titanium nitride (TiN) thin film was used as a buffer layer on the substrate in order to prevent the formation of Co silicide. A dense, vertically aligned, double-walled CNT (DWNT) film was grown rapidly on the Co-catalyzed Si substrate. The CNTs grew at an extremely high rate of 600 nm/s during the first 10 min of growth. Dense DWNT films with thicknesses of over 500 μm were obtained in 20 min. [DOI : 10.1143/JJAP.44.L693]

Keywords: carbon naotube, double-walled CNT, plasma enhanced CVD, Co catalyst, aligned, high growth rate

Nano Factory, Department of Electrical and Electronic Engineering, Meijo University, Tempaku, Nagoya 468-8502, Japan
1 Nano Factory, Department of Materials Science and Engineering, Meijo University, Tempaku, Nagoya 468-8502, Japan
2 Department of Electrical Engineering and Computer Science, Nagoya University, Chikusa, Nagoya 464-8603, Japan

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Current-Induced Plastic Deformation of Double-Walled Carbon Nanotubes

Yoshikazu Nakayama[1,2]*, Atsuko Nagataki[2], Osamu Suekane[2], Xiaoyu Cai[1] and Seiji Akita[1]
(Received April 26, 2005; accepted May 13, 2005; published May 27, 2005)

We induced a permanent plastic deformation in an originally straight double-walled nanotube by applying current to an individual nanotube that had been bent elastically under mechanical duress. This method is controllable and allows nanotubes' application as building blocks in nanostructures. Inserting pentagon–heptagon pairs into a nanotube created bending angles of 20–30°. The onset of plastic deformation, as measured using the current circumference-density, is less than 1/20 that of the sublimation. The onset decreases with increasing nanotube diameter. This process is performed using a transmission electron microscope: electron beam energy is not essential for the process but decreases the onset. [DOI : 10.1143/JJAP.44.L720]

Keywords: carbon nanotubes, double-walled carbon nanotubes, plastic deformation, permanent bend, transmission electron microscope, nanomanipulation

1 Department of Physics and Electronics, Graduate School of Engineering, Osaka Prefecture University, 1-1 Gakuen-cho, Sakai, Osaka 599-8531, Japan
2 Handai Frontier Research Center, Graduate School of Engineering, Osaka University, 2-1 Yamadaoka, Suita, Osaka 565-0871, Japan
* E-mail address: nakayama@pe.osakafu-u.ac.jp

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Photon Antibunching Observed from an InAlAs Single Quantum Dot

Satoshi Kimura[1], Hidekazu Kumano[1], Michiaki Endo[1], Ikuo Suemune[1,3], Tomonori Yokoi[2], Hirotaka Sasakura[3], Satoru Adachi[2,3], Shunichi Muto[2,3], Hai Zhi Song[3,4], Shinichi Hirose[5] and Tatsuya Usuki[3,4]
(Received May 12, 2005; accepted May 22, 2005; published June 10, 2005)

Single-photon emitters and detectors are key devices to realize secure communications with single-photon-based quantum cryptography and single-photon-based quantum computing. InAlAs quantum dots (QDs) cover the wavelength range with high quantum efficiencies of Si-based single-photon detectors. Clear photon antibunching was observed from an InAlAs single QD under weak excitations. To realize single-photon emitters on demand, complete population of the QD energy states before the photon emission events is necessary, but the measured antibunching properties were dependent substantially on the photo-excitation powers. The physical origin of this problem is discussed. The criterion to distinguish the real deviation from the photon antibunching condition and the artifact of the measurements is clarified. The capability of single-photon emissions on demand will be demonstrated with photon antibunching under pulsed operations. [DOI : 10.1143/JJAP.44.L793]

Keywords: photon antibunching, quantum dot, photon correlation measurement, single photon emission, InAlAs

1 RIES, Hokkaido University, Sapporo 001-0021, Japan
2 Department of Applied Physics, Hokkaido Univercity, Sapporo 060-8628, Japan
3 CREST JST, Kawaguchi, Saitama 332-0012, Japan
4 Fujitsu Ltd., 10-1 Morinosato-Wakamiya, Atsugi, Kanagawa 243-0197, Japan
5 Fujitsu Laboratories Ltd., 10-1 Morinosato-Wakamiya, Atsugi, Kanagawa 243-0197, Japan

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Structural Characterization of Thick GaN Films Grown on Free-Standing GaN Seeds by the Ammonothermal Method Using Basic Ammonia

Tadao Hashimoto*, Kenji Fujito, Feng Wu, Benjamin A. Haskell, Paul T. Fini, James S. Speck and Shuji Nakamura
(Received April 30, 2005; accepted May 24, 2005; published June 10, 2005)

Single crystalline GaN was grown on *c*-plane free-standing GaN seeds via fluid transport by the ammonothermal method. Ammonothermal growth was carried out in an ammonobasic solution with a metallic Ga nutrient placed in a lower-temperature zone. The thickest film obtained so far is ~45 μm, which was grown on the N-face of the seed. The growth interface contained numerous voids and defects, whereas the microstructure close to the surface was greatly improved. The major defects close to the surface were mixed-character threading dislocations. The estimated threading dislocation density was low-10^9 cm^{-2} level at the free surface of the N-face. [DOI : 10.1143/JJAP.44.L797]

Keywords: bulk GaN, ammonothermal growth, dislocations, seeded growth, supercritical ammonia

Materials Department and ERATO/JST UCSB Group, University of California, Santa Barbara, CA 93106-5050, U.S.A.
* E-mail address: tadao@engineering.ucsb.edu

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Self-Aligned-Gate Metal/Ferroelectric/Insulator/Semiconductor Field-Effect Transistors with Long Memory Retention

Mitsue Takahashi* and Shigeki Sakai**
(Received May 25, 2005; accepted May 27, 2005; published June 10, 2005)

Self-aligned-gate Pt/$SrBi_2Ta_2O_9$/HfAlO/Si metal/ferroelectric/insulator/semiconductor (MFIS) field-effect transistors (FETs) were fabricated. Drain current (I_d) versus gate voltage curves of the MFIS FETs showed almost the same steepness as that of a non-self-aligned-gate Pt/HfAlO/Si metal/insulator/semiconductor FET. Long retention times with large on- and off-state I_d ratios were obtained for the MFIS FETs. The retention times more than 33 days with an on- and off-state I_d ratio over 10^5 were demonstrated for the self-aligned-gate MFIS FET with a 2-μm-long and 80-μm-wide gate. This device showed the longest memory retention among all of the ferroelectric-gate FETs reported ever before.
[DOI : 10.1143/JJAP.44.L800]

Keywords: metal/ferroelectric/insulator/semiconductor (MFIS), nonvolatile memory, retention, ferroelectric, SBT, HfAlO, 1T FeRAM

National Institute of Advanced Industrial Science and Technology, Central 2, 1-1-1 Umezono, Tsukuba, Ibaraki 305-8568, Japan
* E-mail address: mitsue-takahashi@aist.go.jp
** E-mail address: shigeki.sakai@aist.go.jp

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Nucleation Stages of Carbon Nanotubes on SiC(0001) by Surface Decomposition

Kenjiro Hayashi, Seigi Mizuno, Satoru Tanaka[1], Hiroki Toyoda[1], Hiroshi Tochihara and Ikuo Suemune[1]
(Received April 20, 2005; accepted May 22, 2005; published June 10, 2005)

Nucleation stages of carbon nanotubes (CNTs) on a SiC(0001) Si-face (4° off toward [11\bar20]) by surface decomposition are investigated by means of *in-situ* scanning tunneling microscopy (STM). After a relatively short heating time at 1600°C, moiré patterns and small nuclei appear on the surface due to the evaporation of Si atoms and, as a result of this, surface graphitization. Modelling of the moiré pattern indicates the formation of a single graphene sheet on top of the SiC surface. Local swelling (~1 nm in diameter) of such a graphene sheet, possibly resulting from the compressive stress at the graphene/SiC interface, gives rise to a CNT nucleus. In the stages that follow, the nucleus is continuously and unidirectionally prolonged and rolled-up, which may result in a final form such as a CNT. [DOI : 10.1143/JJAP.44.L803]

Keywords: carbon nanotube, silicon carbide, scanning tunneling microscopy, moiré pattern, surface decomposition

Department of Molecular and Material Sciences, Kyushu University, Fukuoka 816-8580, Japan
1 Research Institute for Electronic Science, Hokkaido University, Sapporo 001-0021, Japan

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Fabrication of DNA Nanofibers on a Planar Surface by Electrospinning

Takuya Takahashi, Masateru Taniguchi* and Tomoji Kawai
(Received April 20, 2005; accepted June 10, 2005; published June 24, 2005)

The electrospinning method was employed for preparing DNA nanofibers on a mica substrate using a high electrostatic field. The DNA nanofibers were examined using atomic force microscopy. It was found that the amount, shape, average height and average length of the nanofibers depended on the experimental conditions. By controlling the applied voltage and the concentration of DNA, we obtained stretched DNA nanofibers at 20 kV and 1.5 wt % with an average height and length of 1.8 nm and 1 μm, respectively. [DOI : 10.1143/JJAP.44.L860]

Keywords: DNA nanofibers, electrospinning

Nanoscience and Nanotechnology Center, The Institute of Scientific and Industrial Research, Osaka University, Osaka 567-0047, Japan
* Corresponding author.

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Strongly Enhanced Sensitivity of Piezoresistive Cantilevers by Utilizing the Superconducting Proximity Effect

Hajime Okamoto*, Tatsushi Akazaki, Mineo Ueki[1] and Hiroshi Yamaguchi
(Received May 18, 2005; accepted June 17, 2005; published July 1, 2005)

We fabricated a novel piezoresistive cantilever that integrates a superconductor–semiconductor–superconductor (S–Sm–S) junction. The cantilever was processed from an InAs/AlGaSb heterostructure and a submicron-size niobium gap was patterned to form a Nb–InAs–Nb junction, at which the deflection of the cantilever can be detected as resistance change, i.e., piezoresistance. The resulting piezoresistance at ~2 K strongly depends on the bias current, and we confirmed that the piezoresistance is enhanced by two orders of magnitude at the critical current, where transition between superconducting state and normal state occurs in the S–Sm–S junction. This indicates that S–Sm–S junctions can be applied for highly sensitive displacement and force sensors. [DOI : 10.1143/JJAP.44.L893]

Keywords: cantilever, MEMS, semiconductor, heterostructure, piezoresistance, superconductor

NTT Basic Research Laboratories, NTT Corporation, Atsugi, Kanagawa 243-0198, Japan
1 NTT Electronics Techno Corporation, Atsugi, Kanagawa 221-0052, Japan
* E-mail address: hajime@nttbrl.jp

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A Ferromagnetic Oxide Semiconductor as Spin Injection Electrode in Magnetic Tunnel Junction

Hidemi Toyosaki, Tomoteru Fukumura*, Kazunori Ueno, Masaki Nakano and Masashi Kawasaki**
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A magnetic tunnel junctions composed of room temperature ferromagnetic semiconductor rutile $Ti_{1-x}Co_xO_{2-\delta}$ and ferromagnetic metal $Fe_{0.1}Co_{0.9}$ separated by AlO_x barrier showed positive tunneling magnetoresistance (TMR) with a ratio of ~11% at 15 K, indicating that $Ti_{1-x}Co_xO_{2-\delta}$ can be used as a spin injection electrode. The TMR decreased with increasing temperature and vanished above 180 K. TMR action at high temperature is likely prohibited by the inelastic tunneling conduction due to the low quality of the amorphous barrier layer and/or the junction interface. [DOI : 10.1143/JJAP.44.L896]

Keywords: tunneling magnetoresistance, ferromagnetic semiconductor, Co-doped TiO_2, magnetic tunnel junction, wide gap semiconductor, oxide semiconductor

Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan
* E-mail address: fukumura@imr.tohoku.ac.jp
** Also at Combinatorial Materials Exploration and Technology (COMET), National Institute for Materials Science, Tsukuba, Ibaraki 305-0044 Japan.

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Characterization of Planar Semipolar Gallium Nitride Films on Spinel Substrates

Troy J. Baker[1,3]*, Benjamin A. Haskell[1,3], Feng Wu[1,3], Paul T. Fini[1,3], James S. Speck[1,3] and Shuji Nakamura[1,2,3]
(Received June 17, 2005; accepted June 23, 2005; published July 8, 2005)

Specular, planar semipolar gallium nitride films were grown by hydride vapor phase epitaxy. This is the first report of high quality semipolar GaN films that could be used for device growth. Planar films of (10-1-1)GaN have been grown on (100)$MgAl_2O_4$ spinel, and planar films of (10-1-3)GaN have been grown on (110)$MgAl_2O_4$ spinel. The in-plane epitaxial relationship for (10-1-1)GaN on (100) spinel was $[10\text{-}1\text{-}2]_{GaN}$ // $[011]_{spinel}$ and $[1\text{-}210]_{GaN}$ // $[0\text{-}11]_{spinel}$. The in-plane epitaxial relationship for (10-1-3)GaN on (110) spinel was $[30\text{-}3\text{-}2]_{GaN}$ // $[001]_{spinel}$ and $[1\text{-}210]_{GaN}$ // $[\text{-}110]_{spinel}$. [DOI : 10.1143/JJAP.44.L920]

Keywords: semipolar, GaN, (10-11), (10-1-1), (10-13), (10-1-3)

1 Materials Department, University of California, Santa Barbara, CA 93106, U.S.A.
2 Electrical Engineering Department, University of California, Santa Barbara, CA 93106, U.S.A.
3 NICP/ERATO JST, UCSB Group, University of California, Santa Barbara, CA 93106, U.S.A.
* E-mail address: tjb@engr.ucsb.edu

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Milliwatt Power Blue InGaN/GaN Light-Emitting Diodes on Semipolar GaN Templates

Arpan Chakraborty, Troy J. Baker*, Benjamin A. Haskell*, Feng Wu*, James S. Speck*, Steven P. Denbaars*, Shuji Nakamura* and Umesh K. Mishra**
(Received June 16, 2005; accepted June 27, 2005; published July 15, 2005)

Growth of semipolar Group-III nitrides based devices offers a means of reducing the deleterious effects of the polarization-induced electric fields present in the polar quantum wells. We report on the fabrication of blue InGaN/GaN multiple-quantum well light-emitting diodes (LEDs) on semipolar (10-1-1) and (10-1-3) oriented GaN templates. A maximum on-wafer continuous wave output power of 190 μW was measured at 20 mA for 300 × 300 μm^2 devices, and output power as high as 1.53 mW was measured at 250 mA. Drive-current independent electroluminescence peak at 439 nm was observed for the LEDs grown on both the planes. The current–voltage characteristics of these LEDs showed rectifying behavior with a forward voltage of 3–4 V at 20 mA. [DOI : 10.1143/JJAP.44.L945]

Keywords: semipolar, InGaN, multiple-quantum well (MQW), light-emitting diode (LED), electroluminescence (EL)

Electrical and Computer Engineering and Materials Departments, University of California, Santa Barbara, CA 93106, U.S.A.
* Also at ERATO JST, UCSB Group, University of California, Santa Barbara, CA 93106, U.S.A.
** E-mail address: mishra@ece.ucsb.edu

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High Curie Temperature and Nano-Scale Spinodal Decomposition Phase in Dilute Magnetic Semiconductors

Kazunori Sato*, Hiroshi Katayama-Yoshida and Peter H. Dederichs[1]
(Received June 6, 2005; accepted June 25, 2005; published July 15, 2005)

We show that spinoadal decomposition phase in dilute magnetic semiconductors (DMS) offers the possibility to have high Curie temperatures (T_C) even if the magnetic exchange interaction is short ranged. The spinodal decomposition is simulated by applying the Monte Carlo method to the Ising model with realistic (*ab initio*) chemical pair interactions between magnetic impurities in DMS. Curie temperatures are estimated by the random phase approximation with taking disorder into account. It is found that the spinodal decomposition phase inherently occurs in DMS due to strong attractive interactions between impurities. This phase decomposition supports magnetic network over the dimension of the crystal resulting in a high-T_C phase. [DOI : 10.1143/JJAP.44.L948]

Keywords: dilute magnetic semiconductor, spinodal decomposition phase, concentration fluctuation, chemical pair interaction, percolation, Curie temperature

The Institute of Scientific and Industrial Research, Osaka University, 8-1 Mihogaoka, Ibaraki, Osaka 567-0047, Japan
1 Institut für Ferskoerperforschung, Forschungszentrum Juelich, D-52425 Juelich, Germany
* E-mail address: ksato@cmp.sanken.osaka-u.ac.jp

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Critical Current Density Enhancement around a Matching Field in $ErBa_2Cu_3O_{7-\delta}$ Films with $BaZrO_3$ Nano-Rods

Masashi Mukaida[1,8]*, Tomoya Horide[2,8], Ryusuke Kita[3,8], Shigeru Horii[4,8], Ataru Ichinose[5,8], Yutaka Yoshida[6,8], Osuke Miura[7,8], Kaname Matsumoto[2,8], Kazuhiro Yamada[1] and Nobuyuki Mori[1]
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Field angular dependences of critical current density are measured for as-grown high crystalline quality $ErBa_2Cu_3O_{7-\delta}$ films with $BaZrO_3$ nano-rods. Large critical current density enhancement is observed. The magnetic field where the enhancement is observed coincides with the matching field calculated from the density of $BaZrO_3$ nano-rods. The largest enhancement is observed in **B** // *c*-axis of $ErBa_2Cu_3O_{7-\delta}$ films. This anisotropic critical current density enhancement is thought to be caused by the direction of $BaZrO_3$ nano-rods which grow along the *c*-axis of the films. $BaZrO_3$ nano-rods in the films will promise the application of coated conductors in a magnetic field. [DOI : 10.1143/JJAP.44.L952]

Keywords: $ErBa_2Cu_3O_{7-\delta}$, $BaZrO_3$ nano-rods, Field angular dependence, pinning center

1 Kyushu University, Hakozaki, Fukuoka, Fukuoka 812-8581, Japan
2 Kyoto University, Yoshidahonmachi, Sakyo-ku, Kyoto 606-8501, Japan
3 Shizuoka University, Johoku, Hamamatsu, Shizuoka 430-8501, Japan
4 University of Tokyo, Hongo, Bunkyo-ku, Tokyo 113-8656, Japan
5 Central Research Institute of Electric Power Industry, Yokosuka, Kanagawa 240-0196, Japan
6 Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8603, Japan
7 Tokyo Metropolitan University, Minamiosawa, Hachioji, Tokyo 192-0397, Japan
8 Japan Science and Technology Agency, Honmachi, Kawaguchi, Saitama 332-0012, Japan
* E-mail address: mukaida@zaiko.kyushu-u.ac.jp

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Highly Tunable Emission from Strain-Induced InGaAsP/InP Quantum Dots

Juha Riikonen*, Jaakko Sormunen, Hannu Koskenvaara, Marco Mattila, Markku Sopanen and Harri Lipsanen
(Received June 23, 2005; accepted July 6, 2005; published July 22, 2005)

Low-temperature photoluminescence (PL), tunable between 1.3 and 1.7 μm, is obtained from strain-induced quantum dots (SIQDs). The quantum dots are fabricated by growing self-assembled InAs stressor islands on top of a near-surface InGaAs(P)/InP quantum well (QW). The structure is tuned by varying the composition of the QW and its distance from the surface. Time-resolved PL measurements reveal that QD relaxation and recombination time constants (0.55 and 0.50 ns) are virtually independent of the composition of the nearly lattice-matched InGaAsP layer. Also, decreasing the QW distance from the surface is shown to shift the energy states and significantly diminish the PL intensity of the SIQD. [DOI : 10.1143/JJAP.44.L976]

Keywords: stressors, InAs islands, self-assembled growth, quantum dot, photoluminescence

Optoelectronics Laboratory, Helsinki University of Technology, P. O. Box 3500, FIN-02015 TKK, Finland
* E-mail address: juha.riikonen@tkk.fi

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Magnetic Behavior of Fe Doped In_2O_3

Shigemi Kohiki, Yusuke Murakawa, Kyoko Hori, Hirokazu Shimooka, Takayuki Tajiri[1], Hiroyuki Deguchi[1], Masaoki Oku[2], Masao Arai[3], Masanori Mitome[3] and Yoshio Bando[3]
(Received June 12, 2005; accepted July 4, 2005; published July 22, 2005)

We report spin-glass transition at room temperature (RT) and cluster-glass behavior below RT for Fe doped In_2O_3 powders with the atomic ratio of In : Fe = 1.85 : 0.15 grown in an oxygen atmosphere. In ac susceptibility, a large peak and a small cusp were observed at RT and \approx30 K, respectively. The peak at RT shifted to higher temperatures with an increase of applied field frequency, while the cusp showed no frequency dependence. Third harmonic nonlinear susceptibility exhibited a divergent peak at RT. Field-cooled dc susceptibility increased almost linearly below RT, whereas zero-field-cooled dc susceptibility deviated below the field-cooled one with lowering temperature. [DOI : 10.1143/JJAP.44.L979]

Keywords: Fe doped In_2O_3, spin-glass transition, cluster-glass behavior

Department of Materials Science, Kyushu Institute of Technology, 1-1 Sensui, Tobata, Kitakyushu 804-8550, Japan
1 Department of Electronic Engineering, Kyushu Institute of Technology, 1-1 Sensui, Tobata, Kitakyushu 804-8550, Japan
2 Institute for Materials Research, Tohoku University, 2-1-1 Katahira, Aoba, Sendai 980-8577, Japan
3 National Institute of Materials Science, 1-1 Namiki, Tsukuba, Ibaraki 305-0044, Japan

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Current Injection Laser Oscillation in TlInGaAs/GaAs Double Quantum Well Diodes with InGaP Cladding Layers

Atsushi Fujiwara, Toshikazu Mukai, Takeshi Matsumoto, Shigehiko Hasegawa and Hajime Asahi*
(Received July 7, 2005; accepted July 6, 2005; published July 29, 2005)

TlInGaAsN/AlGaAs heterostructures were proposed for use in the fabrication of temperature-stable lasing wavelength and threshold current laser diodes. As a first step, we grew TlInGaAs/GaAs quantum well (QW) structures on GaAs(100) substrates and demonstrated an electroluminescence (EL) emission of up to 300 K. Compared with InGaAs/GaAs QWs, we confirmed that the temperature variation of the EL peak energy was decreased by the addition of Tl into InGaAs. We also demonstrated the pulsed current injection laser oscillation in the TlInGaAs/GaAs double QW laser diodes with InGaP cladding layers up to 176 K.
[DOI : 10.1143/JJAP.44.L1002]
Keywords: TlInGaAs, GaAs, semiconductor laser diodes, temperature-insensitive wavelength, molecular beam epitaxy, WDM optical fiber communication

The Institute of Scientific and Industrial Research, Osaka University, 8-1 Mihogaoka, Ibaraki, Osaka 567-0047, Japan
* Corresponding author. E-mail address: asahi@sanken.osaka-u.ac.jp

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Ta-doped Anatase TiO_2 Epitaxial Film as Transparent Conducting Oxide

Taro Hitosugi[1,2]*, Yutaka Furubayashi[2], Atsuki Ueda[1], Kinnosuke Itabashi[3], Kazuhisa Inaba[2,4], Yasushi Hirose[2], Go Kinoda[2], Yukio Yamamoto[2], Toshihiro Shimada[1,2] and Tetsuya Hasegawa[1,2]
(Received July 20, 2005; accepted July 27, 2005; published August 12, 2005)

We present electrical transport and optical properties of Ta-doped TiO_2 epitaxial thin films with varying Ta concentration grown by the pulsed laser deposition method. The $Ti_{0.95}Ta_{0.05}O_2$ film exhibited a resistivity of 2.5×10^{-4} Ω cm at room temperature, and an internal transmittance of 95% in the visible light region. These values are comparable to those of a widely used transparent conducting oxide (TCO), indium tin oxide. Furthermore, this new material falls into a new category of TCOs that utilizes *d* electrons. [DOI : 10.1143/JJAP.44.L1063]
Keywords: pulsed laser deposition, TiO_2, transparent conducting oxide, epitaxial, thin film

1 Department of Chemistry, University of Tokyo, Tokyo 113-0033, Japan
2 Kanagawa Academy of Science and Technology (KAST), Kawasaki 213-0012, Japan
3 Department of Environmental Chemical Engineering, Kogakuin University, Tokyo 163-8677, Japan
4 Materials and Structures Laboratory, Tokyo Institute of Technology, Yokohama 226-8503, Japan
* E-mail address: hitosugi@chem.s.u-tokyo.ac.jp

Jpn. J. Appl. Phys. Vol. 44 (2005) pp. L1066-L1068
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Second-Harmonic-Generation Microscopy Using Excitation Beam with Controlled Polarization Pattern to Determine Three-Dimensional Molecular Orientation

Keisuke Yoshiki, Mamoru Hashimoto* and Tsutomu Araki
(Received July 15, 2005; accepted July 25, 2005; published August 12, 2005)

We have developed a second-harmonic-generation (SHG) microscope using an excitation beam with a controlled polarization pattern in order to detect three-dimensional molecular orientation. The electric field at the focus is controlled three-dimensionally by modifying the polarization distribution with a parallel-aligned nematic-liquid-crystal spatial-light-modulator without any mechanical moving parts. We demonstrated that the SHG signal from an Achilles tendon, sliced so that collagen fibers were aligned parallel to the optical axis, excited by a radially polarized beam was higher than those excited by linearly polarized beams. The possibility of determinating three-dimensional molecular orientation was thus shown.
[DOI : 10.1143/JJAP.44.L1066]
Keywords: three-dimensional molecular orientation, optical microscopy, SHG microscopy, liquid-crystal spatial-light-modulator

Department of Mechanical Science and Bioengineering, Graduate School of Engineering Science, Osaka University, Machikaneyama 1-3, Toyonaka, Osaka 560-8531, Japan
* Corresponding author. E-mail address: mamoru@me.es.osaka-u.ac.jp}

Jpn. J. Appl. Phys. Vol. 44 (2005) pp. L1069-L1071
Part 2, No. 34, 10 August 2005

Achievement of High Density InAs Quantum Dots on InP (311)B Substrate Emitting at 1.55 μm

P. Caroff, N. Bertru*, A. Le Corre, O. Dehaese, T. Rohel, I. Alghoraibi, H. Folliot and S. Loualiche
(Received July 11, 2005; accepted July 15, 2005; published August 12, 2005)

The As flux effect on InAs quantum dots formed by gas source molecular beam epitaxy on InP substrates, oriented following the (311)B crystallographic direction has been studied. Atomic force microscopy images show that the quantum dot (QD) density dramatically increases and quantum dot sizes decrease, when decreasing the As pressure. Moreover, the size dispersion is narrowed. Photoluminescence measurements on the high QD density samples is shifted to higher energy, toward the telecommunication important 1.55 μm emission. [DOI : 10.1143/JJAP.44.L1069]
Keywords: InP, InAs, quantum dots, (311)B surface, molecular beam epitaxy, nanostructures

Laboratoire d'Etude des Nanostructures à Semiconducteurs (LENS), UMR C6082; INSA, 20 Avenue des Buttes de Coësmes, F-35043 Rennes Cedex, France
* E-mail address: Nicolas.bertru@insa-rennes.fr

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Huge Spin-Polarization of $L2_1$-Ordered Co_2MnSi Epitaxial Heusler Alloy Film

Yuya Sakuraba, Jun Nakata, Mikihiko Oogane, Hitoshi Kubota[1], Yasuo Ando, Akimasa Sakuma and Terunobu Miyazaki
(Received July 19, 2005; accepted July 31, 2005; published August 19, 2005)

Magnetic tunnel junctions (MTJs) with a stacking structure of epitaxial Co_2MnSi/Al–O barrier/poly-crystalline $Co_{75}Fe_{25}$ were fabricated using an ultrahigh vacuum sputtering system. The epitaxial Co_2MnSi bottom electrode exhibited highly ordered $L2_1$ structure and very smooth surface morphology. Observed magnetoresistance (MR) ratios of 70% at room temperature (RT) and 159% at 2 K are the highest values to date for MTJs using a Heusler alloy electrode. A high spin-polarization of 0.89 at 2 K for Co_2MnSi obtained from Julliere's model coincided with the half-metallic band structure that was predicted by theoretical calculations.
[DOI : 10.1143/JJAP.44.L1100]

Keywords: Heusler alloy, spin-polarization, half-metal, magnetic tunnel junction, tunnel magnetoresistance

Department of Applied Physics, Graduate School of engineering, Tohoku University, Aoba-yama 05, Aramaki, Aoba-ku, Sendai 980-8579, Japan
1 Nanoelectronics Research Institute, National Institute of Advanced Industrial Science and Technology (AIST), 1-1-1 Umezono, Tsukuba 305-8568, Japan

Jpn. J. Appl. Phys. Vol. 44 (2005) pp. L1103-L1104
Part 2, No. 35, 10 August 2005

InAs Quantum Dot Lasers with Extremely Low Threshold Current Density (7 A/cm^2/Layer)

Hitoshi Shimizu*, Shanmugam Saravanan, Junji Yoshida, Sayoko Ibe[1] and Noriyuki Yokouchi[1]
(Received July 22, 2005; accepted August 4, 2005; published August 19, 2005)

This paper describes the successful stacking of multilayered InAs quantum dots (QD) on a GaAs substrate up to 12 layers. The laser oscillated from the ground state under the condition of mirror loss at less than 7–8 cm^{-1}. The extremely low threshold current density per QD-layer of 7 A/cm^2/layer was obtained with a lasing wavelength of 1.21 μm at room temperature, which is the lowest value for any known semiconductor laser. [DOI : 10.1143/JJAP.44.L1103]
Keywords: laser, quantum dot, InAs, molecular beam epitaxy, threshold current density, multilayer

Department of Nonlinear Science, ATR Wave Engineering Laboratories, 2-2-2 Hikaridai, ``Keihanna Science City", Kyoto 619-0288, Japan
1 Yokohama R&D Laboratories, Furukawa Electric Co., Ltd., 2-4-3 Okano, Nishi-ku, Yokohama 220-0073, Japan
* E-mail address: hshimizu@atr.jp

Jpn. J. Appl. Phys. Vol. 44 (2005) pp. L1105-L1108
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Time-Resolved Measurement of Charging on Hole Bottoms of SiO_2 Wafer Exposed to Plasma Etching in a Pulsed Two-Frequency Capacitively Coupled Plasma

Takeshi Ohmori[1]*, Takeshi Kamata Goto[1], Takeshi Kitajima[1,2] and Toshiaki Makabe[1]*
(Received July 13, 2005; accepted July 30, 2005; published August 19, 2005)

We experimentally demonstrate a time chart of the shading either of electrons or positive ions on a topologically patterned wafer exposed to plasma etching by synchronized measurements of bottom-charging potential in a SiO_2 hole, current components incident on the wafer, and optical emission CT in the interface in a pulsed two frequency capacitively coupled plasma. The present paper gives a history of charging affected dynamically by an instantaneous electrical response on the bottom.
[DOI : 10.1143/JJAP.44.L1105]

Keywords: pulsed 2f-CCP, charging free process, charging in dielectric etching, emission CT, negative charge injection

1 Department of Electronics and Electrical Engineering, Keio University, 3-14-1 Hiyoshi, Kohoku-ku, Yokohama 223-8522, Japan
2 Department of Electrical Eng., National Defense Academy, 1-10-20 Hashirimizu, Yokosuka, Kanagawa 239-8686, Japan
* E-mail address: ohmori@mkbe.elec.keio.ac.jp
** E-mail address: makabe@mkbe.elec.keio.ac.jp

Jpn. J. Appl. Phys. Vol. 44 (2005) pp. L1109-L1111
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Low-Leakage Polymeric Thin-Film Transistors Fabricated by Laser Assisted Lift-Off Technique

Sung-Jin Kim[1,2], Taek Ahn[2], Min Chul Suh[2], Chang-Jae Yu[1], Dong-Woo Kim[1] and Sin-Doo Lee[1]*
(Received July 20, 2005; accepted July 30, 2005; published August 19, 2005)

Organic thin-film transistors (OTFTs) based on a semiconducting polymer have been fabricated using a patterning method of the selective wettability. Laser assisted lift-off (LALO) technique, ablating selectively the hydrophobic layer by an excimer laser, was used for producing a semiconducting polymer channel in the OTFT with high resolution. The selective wettability of a semiconducting polymer, poly(9-9-dioctylfluorene-*co*-bithiophene) (F8T2), dissolved in a polar solvent was found to define precisely the pattering resolution of the active channel. It is demonstrated that in the F8T2 TFTs fabricated using the LALO technique, the leakage of the gate current is drastically reduced. [DOI : 10.1143/JJAP.44.L1109]
Keywords: laser assisted lift-off technique, organic TFT, low leakage current

1 School of Electrical Engineering #32, Seoul National University, Kwanak P.O. Box 34, Seoul 151-742, Korea
2 Corporate R&D Center, Samsung SDI Co., Ltd., 428-5, Gongse-Ri, Kiheung-Eup, Yongin-City, Gyeonggi-Do, 449-902, Korea
* E-mail address: sidlee@plaza.snu.ac.kr

Jpn. J. Appl. Phys. Vol. 44 (2005) pp. L1138-L1140
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High-Critical-Temperature Sm- and Nd-Based Superconductors Produced by Metal Organic Deposition Using Trifluoroacetates and Pentafluoropropionates

Takeshi Araki* and Izumi Hirabayashi
(Received July 27, 2005; accepted August 6, 2005; published August 26, 2005)

Superconducting films for wire, tape, and microwave filter applications require a high critical temperature (T_c) and current density (J_c). Therefore, superconducting systems based on La, Nd, and Sm produced by low-cost non-vacuum metal organic deposition using trifluoroacetates (TFA-MOD) are eagerly awaited. These systems are reported to have excellent T_c values of over 94 K, but esterification between trifluoroacetates and methanol leads to low T_c values in the TFA-MOD process. Two recent studies on carbon expulsion during calcining and on a quasi-liquid network model during firing suggest new effective chemicals and we successfully prepared Nd- and Sm-based superconductors using pentafluoropropionic acid. The best Nd- and Sm-based films exhibited T_c of 93.4 and 93.9 K and J_c of 3.4 and 5.1 MA/cm^2 (77 K, 0 T), as measured by the inductive method, respectively. The film thicknesses were 133 and 181 nm, respectively. [DOI : 10.1143/JJAP.44.L1138]

Keywords: trifluoroacetates, Nd-based superconductor, Sm-based superconductor, metal organic deposition, non-vacuum process, carbon expulsion scheme, quasi-liquid network model, pentafluoropropionic acid

Superconductivity Research Laboratory, 1-10-13 Shinonome, Koto-ku, Tokyo 135-0062, Japan
* Present address: Corporate Research and Development Center, Toshiba Corp., 1 Komukai-Toshiba-cho, Saiwai-ku, Kasawaki 212-8582, Japan.
E-mail address: takeshi2.araki@toshiba.co.jp

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Non-equilibrium Phenomenon between Electron and Lattice Systems Induced by the Peltier Effect

Hideo Iwasaki, Hidenobu Hori and Shosuke Sasaki[1]
(Received July 25, 2005; accepted August 10, 2005; published August 26, 2005)

Temperature distributions of the electron and lattice systems induced by the Peltier effect have been precisely measured by improved Harman method, where the temperature differences (ΔT_{el} and ΔT_{la}) have been independently evaluated for several terminal lengths (L_V) in thermoelectric materials $(Bi,Sb)_2Te_3$. Both temperature distributions have different behaviors in the stationary state, that is, the L_V dependences of ΔT_{el} and ΔT_{la} show positive and negative curvatures, respectively. It is also indicated that the temperature difference has a linear relation to L_V in the whole system and the observed non-equilibrium phenomenon is consistent with a law of the conservation of heat quantity. [DOI : 10.1143/JJAP.44.L1141]

Keywords: non-equilibrium stationary state, electron and lattice system, thermoelectricity, Peltier effect, Harman method

School of Materials Science, JAIST, Nomi, Ishikawa 923-1292, Japan
1 Shizuoka Institute of Science and Technology, Fukuroi, Shizuoka 437-8555, Japan

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First-Principles Materials Design of $CuAlO_2$ Based Dilute Magnetic Semiconducting Oxide

Hidetoshi Kizaki*, Kazunori Sato, Akira Yanase and Hiroshi Katayama-Yoshida
(Received August 9, 2005; accepted August 23, 2005; published September 9, 2005)

The electronic structures and the magnetic properties of dilute magnetic semiconductors (DMSs) based on transparent semiconducting oxide $CuAlO_2$ are calculated by using the Korringa–Kohn–Rostoker method combined with the coherent potential approximation within the local density approximation. We see from the results that we can expect to obtain the half-metallic and high-spin ferromagnetic state is expected to be stable in Mn-, Fe-, Co- and Ni-doped $CuAlO_2$.
[DOI : 10.1143/JJAP.44.L1187]

Keywords: materials design, $CuAlO_2$, delafossite structure, dilute magnetic semiconductor, spintronics, half-metallic density of states

The Institute of Scientific and Industrial Research, Osaka University, 8-1 Mihogaoka, Ibaraki, Osaka 567-0047, Japan
* E-mail address: hide@cmp.sanken.osaka-u.ac.jp

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Strong Excitonic Emission from (001)-Oriented Diamond *P–N* Junction

Toshiharu Makino[1,2]*, Hiromitsu Kato[1,2], Masahiko Ogura[1,2], Hideyuki Watanabe[1,2], Sung-Gi Ri[1,2], Satoshi Yamasaki[1,2,3] and Hideyo Okushi[1,2]
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We have succeeded in fabricating (001)-oriented diamond *p–n* junctions with good diode characteristics and realized UV light emission by current-injection at room temperature. As *p–n* junctions, a phosphorus-doped *n*-type layer was formed on (001)-oriented boron-doped *p*-type one by applying an optimized homoepitaxial growth technique based on micro-wave plasma-enhanced chemical vapor deposition. Current–voltage characteristics showed a rectification ratio of 10^6 at ± 30 V at room temperature. The existence of the space-charge layer through the *p–n* junction was confirmed from capacitance–voltage characteristics. A strong UV light emission at 235 nm was observed at forward current over 20 mA and is attributed to free exciton recombination.
[DOI : 10.1143/JJAP.44.L1190]

Keywords: diamond, chemical vapor deposition, (001)-oriented *p–n* junction, light-emitting diode, exciton

1 Diamond Research Center, National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba Center 2, Tsukuba, Ibaraki 305-8568, Japan
2 Core Research for Evolutional Science and Technology (CREST), Japan Science and Technology Corporation (JST), c/o AIST, Tsukuba, Ibaraki 305-8568, Japan
3 Graduate School of Pure and Applied Science, University of Tsukuba, Tsukuba, Ibaraki 305-8577, Japan
* E-mail address: toshiharu-makino@aist.go.jp

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Evaluation of Spin-Transfer Switching in CoFeB/MgO/CoFeB Magnetic Tunnel Junctions

Hitoshi Kubota[1]*, Akio Fukushima[1], Yuichi Ootani[1], Shinji Yuasa[1,2], Koji Ando[1], Hiroki Maehara[3], Koji Tsunekawa[3], David D. Djayaprawira[3], Naoki Watanabe[3] and Yoshishige Suzuki[1,4]
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Current-induced magnetization switching was demonstrated on Co–Fe–B/MgO/Co–Fe–B magnetic tunnel junctions (MTJs), which exhibited giant tunnel magnetoresistance ratios of about 100%. Switching current density at a pulse duration of 100 ms was about 6×10^6 A/cm^2 at room temperature. The switching current density was reduced to one-third of the smallest value for the MgO-based MTJs reported to date. Dependence of the switching current on pulse duration and on the external magnetic field was discussed based on a theoretical model incorporating thermally activated spin-transfer switching. The spin-transfer switching in the MgO-based MTJs realizes low writing power consumption and a high read-out signal in high-density magnetoresistive random access memory. [DOI : 10.1143/JJAP.44.L1237]

Keywords: spin-transfer switching, MgO, magnetic tunnel junction, switching current density, tunnel magnetoresistance, magnetoresistive random access memory

1 Nanoelectronics Research Institute (NeRI), National Institute of Advanced Industrial Science and Technology (AIST), 1-1-1, Umezono, Tsukuba, Ibaraki 305-8568, Japan
2 PRESTO, Japan Science and Technology Agency (JST), Kawaguchi, Saitama 332-0012, Japan
3 Electron Device Division, ANELVA Corp., 5-8-1 Yotsuya, Fuchu-shi, Tokyo 183-8508, Japan
4 Graduate School of Engineering Science, Osaka University, 1-3 Machikaneyama, Toyonaka, Osaka 560-8531, Japan
* E-mail address: hit-kubota@aist.go.jp

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Colossal Electro-Resistance Memory Effect at Metal/La_2CuO_4 Interfaces

Akihito Sawa[1,2]*, Takeshi Fujii[1,2,3], Masashi Kawasaki[1,3] and Yoshinori Tokura[1,4]
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We have examined the colossal electro-resistance memory effect for the metal/La_2CuO_4 (*M*/LCO) junctions with *M* = Au, Ti, and Al. Among the junctions, the Ti and Al/LCO junctions exhibited hysteretic and nonlinear Schottky-like current–voltage characteristics, whose resistance could also be switched by pulsed voltage stresses. The resistance switching properties are similar to those previously reported in a Ti/$Pr_{0.7}Ca_{0.3}MnO_3$ junctions, and can be attributed to the charging effect at the Schottky-like interface. [DOI : 10.1143/JJAP.44.L1241]

Keywords: Transition-Metal Oxides, Electro-Resistance, Non-volatile memory, Interface, Schottky

1 Correlated Electron Research Center (CERC), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki 305-8562, Japan
2 CREST-JST, Kawaguchi, Saitama 322-0012, Japan
3 Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan
4 Department of Applied Physics, University of Tokyo, Tokyo 113-8656, Japan
* E-mail address: a.sawa@aist.go.jp

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Current-Driven Magnetization Switching in CoFeB/MgO/CoFeB Magnetic Tunnel Junctions

Jun Hayakawa[1,2]*, Shoji Ikeda[2], Young Min Lee[2], Ryutaro Sasaki[2], Toshiyasu Meguro[2], Fumihiro Matsukura[2], Hiromasa Takahashi[1,2] and Hideo Ohno[2]
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Current-driven magnetization switching in low-resistance $Co_{40}Fe_{40}B_{20}$/MgO/$Co_{40}Fe_{40}B_{20}$ magnetic tunnel junctions (MTJs) is reported. The critical-current densities J_c required for current-driven switching in samples annealed at 270 and 300°C are found to be as low as 7.8×10^5 and 8.8×10^5 A/cm^2 with accompanying tunnel magnetoresistance (TMR) ratios of 49 and 73%, respectively. Further annealing of the samples at 350°C increases TMR ratio to 160%, while accompanying J_c increases to 2.5×10^6 A/cm^2. We attribute the low J_c to the high spin-polarization of tunnel current and small M_sV product of the CoFeB single free layer, where M_s is the saturation magnetization and V the volume of the free layer. [DOI : 10.1143/JJAP.44.L1267]

Keywords: current-driven magnetization switching, magnetic tunnel junction, MgO barrier, CoFeB

1 Advanced Research Laboratory, Hitachi, Ltd., 1-280 Higashi-Koigakubo, Kokubunji, Tokyo 185-8601, Japan
2 Laboratory for Nanoelectronics and Spintronics, Research Institute of Electrical Communication, Tohoku University, 2-1-1 Katahira, Aoba-ku, Sendai 980-8577, Japan
* E-mail address: j-hayaka@rd.hitachi.co.jp