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

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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

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Interferometric Computed Tomography Measurement and Novel Expression Method of Discharged Flow Field with Unsteady Shock Waves

Masanori Ota[*], Toshihiro Koga and Kazuo Maeno[1,**]
(Received August 31, 2005; accepted September 15, 2005; published October 7, 2005)

A three-dimensinal interferometric computed tomography (CT) measurement has been applied to the unsteady and high-speed flow field including shock waves. The flow field is induced by shock waves discharged from a pair of circular open ends in the shock tube experiment. The incident shock Mach number is 2.0 and discharged Mach number at the open ends is 2.3. The computational fluid dynamics (CFD) simulation is also applied to this flow field. To implement the detailed discussion of the experimental result along with the CFD result, we propose a novel visualization method named as `distribution combined schlieren image (DCSI)'.
[DOI : 10.1143/JJAP.44.L1293]
Keywords: computed tomography, shock wave, three-dimensional measurement, unsteady flow

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Fast Ambipolar Carrier Transport and Easy Homeotropic Alignment in a Metal-Free Phthalocyanine Derivative

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(Received September 16, 2005; accepted September 28, 2005; published October 14, 2005)

We have investigated charge carrier transport in the various phases of the metal-free phthalocyanine derivative, 1,4,8,11,15,18,22,25-octaoctylphthalocyanine ($8H_2Pc$), by the time-of-flight method. The discotic columnar phase of $8H_2Pc$ easily self-organizes in columns perpendicular to the substrate when cooled from the isotropic phase. We found that well-defined transits were observed, not only for positive carriers, but also for negative carriers. For the columnar rectangular phase at 85°C the hole and electron mobilities were very high at 0.2 and 0.3 cm^2/(V·s), respectively. These mobilities depend on neither electric field nor temperature. This ambipolar carrier transport was easily observed even in an ambient atmosphere. Interestingly, the mobility in the isotropic phase was of the order of 10^{-3} cm^2/(V·s) and did not depend on temperature, which suggests that the electronic conduction is governed by charge carrier transport in that phase as well. [DOI : 10.1143/JJAP.44.L1310]
Keywords: ambipolar carrier transport, discotic liquid crystal, electronic transport, phthalocyanine derivative, electron mobility, time-of-flight method

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Super-Accurate Velocity Measurement for Evaluating TiO_2–SiO_2 Ultra-Low-Expansion Glass Using the Line-Focus-Beam Ultrasonic Material Characterization System

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(Received September 8, 2005; accepted September 28, 2005; published October 14, 2005)

A method of improving the measurement accuracy of leaky surface acoustic wave (LSAW) velocity for TiO_2-doped SiO_2 ultra-low-expansion glass using the line-focus-beam ultrasonic material characterization (LFB-UMC) system was investigated theoretically and experimentally. The frequency dependence of the interference waveform attenuation in a $V(z)$ curve obtained for the glass was calculated by considering the propagation attenuation of LSAWs. The theoretical results revealed that the waveform attenuation depends primarily on acoustic energy loss due to the water-loading effect on the specimen surface, and that the waveform attenuation decreases with decreasing frequency. Significant improvement of the measurement accuracy was successfully demonstrated by using an LFB ultrasonic device with a larger curvature radius R of the cylindrical sapphire acoustic lens, R=2.0 mm, yielding an improved value of ±0.0020% obtained at 75MHz, as compared to ±0.0053% obtained at 225MHz with a cylindrical lens of R=1.0 mm. [DOI : 10.1143/JJAP.44.L1313]

Keywords: line-focus-beam ultrasonic material characterization system, velocity measurement, leaky surface acoustic wave, ultra-low-expansion glass, TiO_2-doped SiO_2 glass, CTE evaluation, EUVL system

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Bipolar Room Temperature Ferromagnetic Semiconductor LaMnOP

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(Received September 29, 2005; accepted October 2, 2005; published October 21, 2005)

We have discovered a high-temperature ferromagnetic semiconductor in which carrier polarity can be changed by impurity doping. A layered compound of lanthanum manganese oxy-phosphide LaMnOP, which is a ferromagnetic material with a Curie temperature of ~320 K, exhibits bipolar conduction by the substitution of La^{3+} sites with Ca^{2+} (hole doping) or Zr^{4+} (electron doping). Ferromagnetic interaction between the Mn^{2+} ions is changed in opposite direction by the carrier doping of a different charge polarity; the Curie temperature (T_c) is monotonically increased to ~600 K by the hole doping, whereas the ferromagnetic interaction is remarkably reduced by the electron doping and 5% Zr^{4+}-doped LaMnOP becomes paramagnetic. This finding provides an opportunity to realize bipolar magnetic transistors that can operate at room temperature.
[DOI : 10.1143/JJAP.44.L1344]

Keywords: magnetic semiconductor, bipolar semiconductor, room temperature ferromagnet, magnetoresistance, layered structure, manganese oxy-phosphide

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Hall Effect of Quasi-Hole Gas in Organic Single-Crystal Transistors

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(Received October 17, 2005; accepted October 19, 2005; published November 4, 2005)

Hall effect is detected in organic field-effect transistors, using appropriately shaped rubrene ($C_{42}H_{28}$) single crystals. It turned out that inverse Hall coefficient, having a positive sign, is close to the amount of electric-field induced charge upon the hole accumulation. The presence of the normal Hall effect means that the electromagnetic character of the surface charge is not of hopping carriers but resembles that of a two-dimensional hole-gas system. [DOI : 10.1143/JJAP.44.L1393]

Keywords: organic field-effect transistor, OFET, Hall effect, rubrene, single-crystal FET

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Flat Band Voltage Shifts in Pentacene Organic Thin-Film Transistors

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(Received September 1, 2005; accepted October 25, 2005; published November 11, 2005)

We have identified the mechanism of capacitance–voltage (C–V) hysteresis behavior often observed in pentacene organic thin-film transistors (OTFTs). The C–V characteristics were measured for pentacene OTFTs fabricated on glass substrates with MoW as gate/source/drain electrode and tetraethoxysilane (TEOS) SiO_2 as gate insulator. The measurements were made at room temperature and elevated temperatures. From the room temperature measurements, we found that the hysteresis behavior was caused by hole injection into the gate insulator from the pentacene semiconductor for large negative gate voltages, resulting in the negative flat-band voltage shift. However electron injection was observed only at elevated temperatures. [DOI : 10.1143/JJAP.44.L1414]

Keywords: C–V hysteresis behavior, organic TFT

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Precipitation of Amorphous Ferromagnetic Semiconductor Phase in Epitaxially Grown Mn-Doped Ge Thin Films

Satoshi Sugahara[1,2,*], Kok Leong Lee[1], Shinsuke Yada[1] and Masaaki Tanaka[1,3]
(Received October 26, 2005; accepted November 1, 2005; published November 18, 2005)

We investigated the origin of ferromagnetism in epitaxially grown Mn-doped Ge thin films. Using low-temperature molecular beam epitaxy, Mn-doped Ge films were successfully grown without precipitation of ferromagnetic Ge–Mn intermetallic compounds, such as Mn_5Ge_3. Magnetic circular dichroism measurements revealed that the epitaxially grown Mn-doped Ge films exhibited clear ferromagnetic behavior, but the Zeeman splitting observed at the critical points was not induced by the s,p–d exchange interactions. High-resolution transmission electron microscopy and energy dispersive X-ray spectroscopy analyses show phase separation of amorphous $Ge_{1-x}Mn_x$ clusters with high Mn content from a Mn-free monocrystalline Ge matrix. Since amorphous $Ge_{1-x}Mn_x$ was characterized as a homogeneous ferromagnetic semiconductor, the precipitation of the amorphous $Ge_{1-x}Mn_x$ clusters is the origin of the ferromagnetic semiconductor behavior of the epitaxially grown Mn-doped Ge films.
[DOI : 10.1143/JJAP.44.L1426]

Keywords: spintronics, ferromagnetic semiconductor, magnetism, germanium, manganese, magnetic circular dichroism, molecular beam epitaxy

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Highly Stable a-Si:H Films Deposited by Using Multi-Hollow Plasma Chemical Vapor Deposition

Kazunori Koga[*], Toshihisa Inoue, Kouki Bando, Shinya Iwashita, Masaharu Shiratani and Yukio Watanabe[**]
(Received October 27, 2005; accepted November 2, 2005; published November 18, 2005)

Hydrogenated amorphous silicon (a-Si:H) films of high stability against light exposure have been deposited by using a newly developed multi-hollow plasma chemical vapor deposition (CVD) method. Films deposited in the upstream region in the multi-hollow plasma CVD reactor are a-Si:H films without incorporating a-Si:H nano-particles (clusters), while those in the downstream region are a-Si:H films with incorporating clusters. A-Si:H films without clusters have a low initial defect density of 5×10^{15} cm^{-3} and keep the value even after 100 h exposure of intense light intensity of 240 mW/cm^2, whereas a-Si:H films with clusters show a significant increase in defect density from its initial value of 5×10^{15} cm^{-3} to 2×10^{16} cm^{-3} after 100 h light exposure. These results indicate that suppression of clusters incorporated into films is the key to realizing highly stable a-Si:H films. [DOI : 10.1143/JJAP.44.L1430]

Keywords: hydrogenated amorphous silicon films, light-induced degradation, Staebler–Wronski effects, plasma CVD, clusters, defect density

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A Palm-Size Ultraviolet Laser Using a Combination of a Monolithic Wavelength Converter and an Optical Fiber

Satoshi Hatano[1,2], Satoshi Ito[2], Masashi Yoshimura[1], Yusuke Mori[1] and Takatomo Sasaki[1]
(Received November 8, 2005; accepted November 11, 2005; published November 25, 2005)

We have developed a monolithic wavelength converter which is composed of optically contacted $KTiOPO_4$ and $Gd_xY_{1-x}Ca_4O(BO_3)_3$. It generates an ultraviolet (UV) light at 0.355 μm just by the incidence of a near-infrared laser at 1.064 μm. Moreover, the converter is attached to the end of an optical fiber which is delivering a near-infrared light to fabricate an extremely compact UV laser. A palm-size UV laser generates an output power of 120 mW at a repetition rate of 60 kHz.
[DOI : 10.1143/JJAP.44.L1466]

Keywords: ultraviolet laser, monolithic wavelength converter, optical fiber, nonlinear optical crystal, harmonic generation, polarization

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Uniaxial Alignment of Alq_3 by Laser-Assisted Molecular Beam Epitaxy

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(Received October 25, 2005; accepted November 4, 2005; published November 25, 2005)

The surface morphology of tris(8-hydroxyquinoline)aluminum(III) (Alq_3) epitaxially grown on KCl(001) was drastically changed by a simultaneous blue laser irradiation during vacuum deposition. Needle-shaped microcrystals were aligned to the polarization direction of the laser, parallel to the KCl[010] axis. The origin of alignment was discussed in comparison with the growth of non-polar organic molecular films, in which anisotropic heating played an important role. [DOI : 10.1143/JJAP.44.L1469]

Keywords: Alq_3, alignment, laser-assisted molecular beam epitaxy, polar molecules, quinacridone

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Heteroepitaxial Growth of Rutile TiO_2 on GaN(0001) by Pulsed Laser Deposition

Taro Hitosugi[1,2,*], Yasushi Hirose[2], Junpei Kasai[2], Yutaka Furubayashi[2], Makoto Ohtani[2], Kiyomi Nakajima[3], Toyohiro Chikyow[3], Toshihiro Shimada[1,2] and Tetsuya Hasegawa[1,2]
(Received October 22, 2005; accepted November 15, 2005; published December 2, 2005)

Rutile TiO_2(100) thin films have been grown on GaN(0001) surfaces by using the pulsed laser deposition method. Reflection high-energy electron diffraction (RHEED) measurements during the deposition clearly revealed the layer-by-layer growth of TiO_2 at a substrate temperature of 400°C under an oxygen pressure of 1×10^{-5} Torr. X-ray diffraction and atomic force microscopy confirmed that the obtained films have high crystallinity with atomically flat surfaces. Pole figure measurements revealed the epitaxial relationship between TiO_2 and GaN, namely that the in-plane $TiO_2\langle 010\rangle$ axis aligns parallel to the GaN$\langle 10\bar{1}0\rangle$.
[DOI : 10.1143/JJAP.44.L1503]

Keywords: pulsed laser deposition, PLD, TiO_2, GaN, epitaxial, thin film, gallium nitride, heteroepitaxial

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BGaN Micro-Islands as Novel Buffers for GaN Hetero-Epitaxy

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(Received November 2, 2005; accepted November 11, 2005; published December 2, 2005)

$B_xGa_{1-x}N$ (x~ 0.02) micro-islands provide novel buffers for growing GaN films and AlGaN/GaN heterostructures on sapphire substrates. These films and heterostructures show low threading dislocation density (TDD), low residual carrier concentration, and high two-dimensional electron gas (2DEG) mobility: Non-doped GaN films had the TDD of 2×10^8 cm^{-2} and the residual electron concentration of 9.4×10^9 cm^{-3} at 433 K. AlGaN/GaN heterostructures exhibited 2DEG Hall mobility of 1720 and 13100 cm^2 V^{-1} s^{-1} at 300 and 77 K, respectively. An almost constant sheet electron density ($2.9–4.2 \times 10^{12}$ cm^{-2}) was obtained in the wide temperature range from 500 to 77 K, indicating the absence of parallel conduction in the GaN buffer layers. [DOI : 10.1143/JJAP.44.L1506]

Keywords: epitaxy, GaN, sapphire, BGaN, boron, dislocation, semi-insulating, AlGaN/GaN heterostructure, two-dimensional electron gas, memory effect

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Fabrication of Nanoparticle Composite Porous Films Having Ultralow Dielectric Constant

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(Received November 2, 2005; accepted November 15, 2005; published December 2, 2005)

Nanoparticle composite porous films having a dielectric constant of $\varepsilon_r = 1.7–3.5$ have been deposited using plasma chemical vapor deposition. Nanoparticles as *nano-building blocks* and radicals as *adhesives* are generated in plasmas, and nanoparticles are deposited together with radicals on substrates to form porous films. Nano-sized pores are dispersed in the films and their dielectric constants are controlled by the concentrations of pores, i.e., their porosities. The method is applicable to depositing nanoparticle composite porous films for other applications.
[DOI : 10.1143/JJAP.44.L1509]

Keywords: plasma CVD, low-*k*, nanoparticles, LSI, ILD, porous film, dielectric constant

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Nano-Domain Engineering in $LiNbO_3$ by Focused Ion Beam

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(Received November 2, 2005; accepted November 18, 2005; published December 9, 2005)

Domain tailored ferroelectric crystals are fascinating functional materials. This needs a simple and highly productive domain engineering method at the micro- and nano-scales. In this letter, penetrating dot domain of top and bottom diameters of 360 and 310 nm, respectively, in 100-μm-thick stoichiometric $LiNbO_3$ by focused ion beam domain engineering has been demonstrated. Surface structures of the same size can be fabricated by combining this focused ion beam domain engineering with HF-selective etching. [DOI : 10.1143/JJAP.44.L1550]

Keywords: domain engineering, focused ion beam, $LiNbO_3$

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Nanoholes Formed by Au Particles Digging into GaAs and InP Substrates by Reverse Vapor–Liquid–Solid Mechanism

Kouta Tateno*, Hideki Gotoh and Hidetoshi Nakano
(Received November 10, 2005; accepted November 18, 2005; published December 9, 2005)

Under a CBr_4 gas supply, Au nanoparticles dig into GaAs and InP substrates to form nanoholes through the reverse vapor–liquid–solid mechanism. The nanohole formation tends to proceed in the [111]B direction. For GaAs, straight holes sometimes appear in the [011] and [211]B directions. This is due to the stable {111}B facets, which block the etching. For InP, many straight holes are seen in the [111]B direction. For both materials, direct etching of the surface also occurs. It is therefore necessary to find the optimum etching conditions for high selectivity to fabricate nanoholes. [DOI : 10.1143/JJAP.44.L1553]

Keywords: nanohole, GaAs, InP, CBr_4, etching, scanning electron microscope

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Ammonothermal Growth of GaN on an over-1-inch Seed Crystal

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(Received November 22, 2005; accepted November 30, 2005; published December 16, 2005)

GaN was grown on a 3 × 4 cm^2 oval-shaped GaN seed crystal by the ammonothermal method. About 15-μm-thick GaN films were uniformly grown on each side of the seed. The Ga-polar surface was filled with pits whereas the N-polar surface was featureless. The photoluminescence (PL) characterization also indicated qualitatively uniform optical properties on each side of the crystal. The PL emission from the Ga-face was dominated by the yellow luminescence whereas that from the N-face showed dominant band-edge emission. These preliminary characterization indicated qualitatively uniform growth of GaN on an over-1″ seed and demonstrated the scalability of the ammonothermal method.
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Keywords: bulk GaN, ammonothermal growth, seeded growth, supercritical ammonia

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Floating Nanodot Gate Memory Devices Based on Biomineralized Inorganic Nanodot Array as a Storage Node

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The memory effect in floating nanodot gate field-effect-transistor (FET) was investigated by fabricating biomineralized inorganic nanodot embedded metal–oxide–semiconductor (MOS) devices. Artificially biomineralized cobalt (Co) oxide cores accommodated in ferritins were utilized as a charge storage node of floating gate memory. Two dimensional array of Co oxide core accommodated ferritin were, after selective protein elimination, buried into the stacked dielectric layers of MOS capacitors and MOSFETs. Fabricated MOS capacitors and MOSFETs presented a clear hysteresis in capacitance–voltage (C–V) characteristics and drain current–gate voltage (I_D–V_G) characteristics, respectively. The observed hysteresis in C–V and I_D–V_G are attributed to the electron and hole confinement within the embedded ferritin cores. These results clearly support the biologically synthesized cores work as charge storage nodes. This work proved the feasibility of the biological path for fabrication of electronic device components. [DOI : 10.1143/JJAP.45.L1]

Keywords: ferritin, biomineralized nanodot, floating gate memory, MOS device, memory effect

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Improvement of Critical Current Density Uniformity for Interface-Modified Josephson Junctions in Single Flux Quantum Circuits

Hironori Wakana*, Seiji Adachi, Yoshinobu Tarutani, Koji Tsubone, Kohei Nakayama and Keiichi Tanabe
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We have investigated the distribution of critical current density (J_c) for interface-modified ramp-edge Josephson junctions in high-T_c single flux quantum (SFQ) circuits. The 1σ spread of J_c in a toggle flip-flop test circuit with a conventional layout is 26.7% and much larger than typical values obtained for junction series-arrays. It is found that the large spread comes from the substantial dependence of J_c on the size of base electrodes, which seems associated with a difference in their surface temperature during deposition of a counter electrode and the formation mechanism of interface-modified junctions. By employing separated base electrodes with similar size in a circuit layout, the J_c spread was drastically reduced to 8.4%, which is almost the same as typical values for junction arrays.
[DOI : 10.1143/JJAP.45.L105]

Keywords: SFQ circuit, high temperature superconductor, ramp-edge junction

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Annealing and Aging Effect in 0.95 $Pb(Zr_{0.52}Ti_{0.48})O_3$–0.05 $NiFe_{1.9}Mn_{0.1}O_4$ Particulate Magnetoelectric Composites

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The results in this letter show the possibility of realizing a high magnetoelectric (ME) coefficient material by synthesizing the particulate composites of ferroelectric and ferromagnetic components using the annealing and aging treatment. The ME composites were fabricated using a combination of conventional mixed oxide sintering and thermal treatment. The thermal treatment constituted of annealing at temperature closer to calcination temperature (~800°C) followed by aging at lower temperatures (300–400°C). Microstructure of the fabricated samples was analyzed using the X-ray mapping in scanning electron microscopy (SEM) and it was found that $NiFe_{1.9}Mn_{0.1}O_4$ (NFM) is distributed inside the $Pb(Zr_{0.52}Ti_{0.48})O_3$ (PZT) grains on the length scales of 100 nm. The magnitude of piezoelectric constant (d_{33}) and the dielectric constant exhibited significant variation with aging time and temperature. It was found that the magnitude of ME coefficient for PZT–5NFM sample increased from 37 to 56 mV/cm·Oe after thermal treatment, an enhancement of ~50%.
[DOI : 10.1143/JJAP.45.L128]
Keywords: piezoelectric, magnetoelectric, ferroelectric, ferromagnetic, PZT, nickel ferrite

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Self-Consistent Modeling of Feature Profile Evolution in Plasma Etching and Deposition

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We investigate the relationship between local wall charging and the feature profile in a SiO_2 trench pattern, by considering the transport of electrons, positive ions, and neutral radicals from the two-dimensional sheath structure in a two frequency-capacitively coupled plasma in CF_4(5%)/Ar. Emphasis is given on the influence of both charging and neutral radical accumulation inside the SiO_2 trench during plasma etching. Feature profiles of the SiO_2 trench are estimated by the Level Set method under conditions with/without charging and neutral deposition.
[DOI : 10.1143/JJAP.45.L132]
Keywords: SiO_2 etching, feature profile evolution, plasma process, surface charging, competitive process

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Ferroelectricity Down to at Least 2 nm in Multiferroic $BiFeO_3$ Epitaxial Thin Films

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(Received December 24, 2005; accepted January 25, 2006; published online February 10, 2006)

We report here on the preservation of ferroelectricity down to 2 nm in $BiFeO_3$ ultrathin films. The electric polarization can be switched reversibly and is stable over several days. Our findings bring insight on the fundamental problem of ferroelectricity at low thickness and confirm the potential of $BiFeO_3$ as a lead-free ferroelectric and multiferroic material for nanoscale devices. [DOI : 10.1143/JJAP.45.L187]
Keywords: $BiFeO_3$, multiferroic, ferroelectric, critical thickness, piezoelectric force microscope

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Observation of Incubation Times in the Nucleation of Silicon Nanowires Obtained by the Vapor–Liquid–Solid Method

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We report the observation of a characteristic incubation time in the growth of silicon nanowires using the vapor–liquid–solid growth mechanism. This incubation time manifests itself during the growth process as a characteristic time delay in the range of several seconds to minutes, prior to which no nanowires are formed. The observation is in excellent agreement with a theoretical model based on the diffusion of silicon through the catalyst, which predicts the presence of an incubation time, as determined by diffusion of the growth constituent through the solid catalyst. Furthermore the theoretical dependence of the incubation time on the activation energy is derived, and validated experimentally for the first time by measuring the incubation times of silicon nanowires obtained by chemical vapor deposition for both gold and copper as a catalyst. The experimentally observed incubation times are in excellent agreement with the theoretically predicted incubation times. The reported incubation times are a universal feature of vapor–liquid–solid growth and can be applied to any other metal/semiconductor system for the synthesis of nanowires and provide a novel route to determine the phase space for nanowire-synthesis. [DOI : 10.1143/JJAP.45.L190]
Keywords: nanowire, silicon, growth mechanism, VLS

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Control of Measurement Environments for High-Efficiency Organic Photovoltaic Cells

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(Received December 15, 2005; accepted January 19, 2006; published online February 17, 2006)

To fabricate a high-performance of organic photovoltaic (PV) cells, not only short-circuit photocurrent density (I_{sc}), but also fill factor (*FF*) should be improved. Here, we improved *FF* by controlling the measurement environment. Because of the prevention of electron trapping by oxygen in the organic semiconducting layer, *FF* in vacuum environment increased 40% compared with that in air under 80 mW/cm^2 irradiation of air mass 1.5 global solar conditions at room temperature. Finally, we obtained a power conversion efficiency of 3.6% by controlling the measurement environment and the optimization of the organic PV cell structure, where *FF* was markedly improved up to 0.61. [DOI : 10.1143/JJAP.45.L217]

Keywords: organic thin-film solar cell, organic semiconductor, photovoltaic, fill factor, ZnPc, C_{60}

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Fabrication of a Vertical-Channel Double-Gate Metal–Oxide–Semiconductor Field-Effect Transistor Using a Neutral Beam Etching

Kazuhiko Endo, Shuichi Noda[1], Meishoku Masahara, Tomohiro Kubota[1], Takuya Ozaki[1], Seiji Samukawa[1], Yongxun Liu, Kenichi Ishii, Yuki Ishikawa, Etsuro Sugimata, Takashi Matsukawa, Hidenori Takashima, Hiromi Yamauchi and Eiichi Suzuki
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A vertical ultrathin-channel (UTC) formation process using a low-energy neutral beam etching (NBE) for a double-gate (DG) metal–oxide–semiconductor field-effect transistor (MOSFET) is proposed for the first time. The NBE can perfectly eliminate the charge build-up and photon radiation damages from the plasma. By utilizing the NBE, fin-type vertical MOSFETs with damage-less smooth sidewalls were successfully fabricated. The fabricated FinFETs realized higher electron mobility than that using a conventional reactive ion etching. The improved mobility is well explained by the atomically-flat surface utilizing by the NBE.
[DOI : 10.1143/JJAP.45.L279]

Keywords: double-gate MOSFET, neutral beam, etching, damage-less, mobility

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Ideal Liquid Crystal Display Mode Using Achiral Banana-Shaped Liquid Crystals

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(Received February 3, 2006; accepted February 15, 2006; published online March 3, 2006)

We have demonstrated a totally new liquid crystal display (LCD) mode using a smectic A-like phase of banana-shaped molecules. An in-plane electric field was applied to homeotropically aligned cells, resulting in fast polarization reorientation and the associated birefringence. The reported LCD mode has all the advantages of the existing LCD modes, such as vertical alignment (VA), in-plane switching (IPS), ferroelectric LC (FLC) or antiferroelectric LC (AFLC) and V-shaped switching (VS) modes; namely, fast response of the order of 100 μs, high contrast ratio (3000:1), wide viewing angle, continuous gray level, and small threshold voltage. These performances originate from the cooperative motion of bent molecules with quasi-long-range order of dipoles based on a two-dimensional Langevin process. [DOI : 10.1143/JJAP.45.L282]

Keywords: liquid crystal display, response time, contrast ratio, viewing angle, Langevin process, ferroelectric switching, SHG

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Avalanche Characteristics of the Te-Doped Amorphous Se Photoconductive Target for a Complementary Metal–Oxide–Semiconductor Image Sensor

Wug-Dong Park and Kenkichi Tanioka[1]
(Received February 20, 2006; accepted February 22, 2006; published online March 10, 2006)

We investigated the avalanche characteristics of the amorphous Se (a-Se) high-gain avalanche rushing amorphous photoconductor (HARP) photoconductive target for a complementary metal–oxide–semiconductor (CMOS) image sensor. To improve the quantum efficiency of the a-Se photoconductive target, thin a-Se layer was doped with Te. Te concentration of the Te-doped a-Se layer within the 0.4-μm-thick a-Se HARP film was 15 wt.%. In the avalanche multiplication phenomena of the a-Se HARP target, the photocurrent is affected by the ionization of the a-Se atom due to hole accelerated at a high electric field. The avalanche multiplication factor and hole ionization rate of the Te-doped a-Se HARP target exponentially increased with increasing target voltage. Also the spectral response of the Te-doped a-Se HARP photoconductive target for a CMOS image sensor was dependent on the target voltage.
[DOI : 10.1143/JJAP.45.L307]

Keywords: photoconductive layer, photoconductive target, photocurrent, a-Se, avalanche multiplication factor, hole ionization rate, spectral response, quantum efficiency

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High-Speed Resistive Switching of TiO_2/TiN Nano-Crystalline Thin Film

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High-speed resistive switching was observed in a TiO_2/TiN nano-crystalline thin film sandwiched between platinum electrodes. A low resistance state was achieved by applying a single negative 2.0-V amplitude 20-ns wide electric pulse, while a high resistance state was achieved by applying a single positive 2.2-V amplitude 30-ns wide electric pulse. So-called forming process, heating bit material by current flow to form conductive filament path before the resistive switching operation was not required. There was an approximately 40,000% increase in resistive change that was repeatedly obtained in the system.
[DOI : 10.1143/JJAP.45.L310]

Keywords: resistive switching, TiN, TiO_2, nano-crystalline, platinum electrode, thin film

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Organic Field-Effect Transistors Based on Oligo-*p*-Phenylenevinylene Derivatives

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(Received February 17, 2006; accepted February 22, 2006; published online March 10, 2006)

Organic field-effect transistors (OFETs) have been fabricated using thermally vacuum-evaporated films of two oligo-*p*-phenylenevinylenes, 1,4-bis(4-methylstyryl)benzene (4MSB), and 1,4-bis(2-methylstyryl)benzene (2MSB). From the electrical characteristics of the OFETs, a field-effect mobility of the 4MSB films was calculated to be 0.13 $cm^2\ V^{-1}\ s^{-1}$, while the mobility of the 2MSB films was $1.0 \times 10^{-4}\ cm^2\ V^{-1}\ s^{-1}$. The mobility of 4MSB is comparable to that of widely studied organic semiconductors, such as oligothiophenes and pentacene. From atomic force microscopy and X-ray diffraction, densely-packed submicron-size grains with a high degree of molecular order were observed in a vacuum-sublimed 4MSB film. [DOI : 10.1143/JJAP.45.L313]

Keywords: organic field-effect transistor, oligo-*p*-phenylenevinylene, mobility, organic semiconductor, oligomer

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Polarity Determination of InN by Atomic Hydrogen Irradiation

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We have succeeded in determining the polarity of InN by atomic hydrogen (H^*) irradiation for the first time. The surface of N- and In-polar InN films was exposed to H^* at nominal temperatures between 200 and 500°C for 30 to 90 min. After H^* irradiation, indium (In) droplets appeared on the surface of N-polar InN, whereas they did not appear on In-polar InN. As the sample temperature was raised, the size of the In droplets on N-polar InN became bigger; furthermore the thickness of the remaining InN layers decreased. On the contrary, the thickness of In-polar InN layers remained unchanged. The mechanisms for these polarity-dependent surface behaviors are discussed. We propose H^* irradiation as one of the promising methods for the polarity determination of InN.
[DOI : 10.1143/JJAP.45.L384]

Keywords: InN, polarity, atomic hydrogen irradiation

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Enhancement of Magneto-Optical Properties of Anatase Co:TiO_2 Co-Doped with Nb

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We have fabricated $Ti_{0.95-x}Nb_xCo_{0.05}O_2$ thin films by the pulsed laser deposition technique. Carrier density was found to be almost identical to the Nb concentration up to x=0.06, indicating that doped Nb atoms generate carriers with >80% efficiency. In this doping range, magneto-optical properties were significantly enhanced by Nb-doping. The remanent Faraday rotation at a wavelength of 405 nm was as high as 5.6×10^3 deg/cm, which is approximately one order of magnitude higher than that of a film free of Nb-doping. The present results support the hypothesis that conduction electrons play an essential role in the ferromagnetism of Co-doped TiO_2. [DOI : 10.1143/JJAP.45.L387]

Keywords: TiO_2, ferromagnetism, diluted magnetic semiconductor, DMS, epitaxial, thin film, Co-doping, pulsed laser deposition, PLD

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