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RESEARCH LETTERS

Evaluation of novel carrier substrates for high reliability and integrated GaN devices in a 200 mm CMOS compatible process

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In this paper new materials and substrate approaches are discussed that have potential to provide (Al)GaN buffers with a better crystal quality, higher critical electrical field, or thickness and have the potential to offer co-integration of GaN switches at different reference potentials, while maintaining lower wafer bow and maintaining complementary metal–oxide semiconductor (CMOS) compatibility. Engineered silicon substrates, silicon on insulator (SOI) and coefficient of thermal expansion (CTE)-matched substrates have been investigated and benchmarked with respect to each other. SOI and CTE-matched offer benefits for scaling to higher voltage, while a trench isolation process combined with an oxide interlayer substrate allows co-integration of GaN components in a GaN-integrated circuit (IC). DOI:10.1557/mrc.2018.192

High throughput fabrication of curcumin embedded gelatin-polylactic acid forcespun fiber-aligned scaffolds for the controlled release of curcumin

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The aim of the current study is to fabricate implantable curcumin embedded gelatin/polylactic acid/curcumin (GL/PLA/Cur) aligned fiber scaffolds by forcespinning®, which might have a potential application in drug delivery and cancer therapy. Fourier Transform Infrared Spectroscopy reveals the hydrogen bonding interactions between GL, PLA, and curcumin. *In vitro* curcumin drug release from GL/PLA/Cur fiber scaffolds is investigated, and sustained release is observed over 15 days. Further, cell viability assay reveals that GL/PLA/Cur aligned fibers show excellent growth of human fibroblast cells. These results strongly suggest that the curcumin bearing GL/PLA/Cur composite fibers may show the potential application in cancer therapy, drug delivery, and wound dressing. DOI:10.1557/mrc.2018.193

Surface modification of L605 by oxygen plasma immersion ion implantation for biomedical applications

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Co–Cr alloys, more specifically L605, have superior mechanical properties and high-corrosion resistance, making them suitable materials for cardiovascular application. However, metallic materials for biomedical applications require finely tuned surface properties to improve the material behavior in a physiological environment. Oxygen plasma immersion ion implantation was performed on an L605 alloy, after an electropolishing pre-treatment. The oxidized layer was found to be rich in Co and O, it did not show any trace of Cr, and resulted in a nanoscale structure. The corrosion properties were profoundly changed. Endothelial cells showed high viability after 7 days of contact with some modified surfaces. DOI:10.1557/mrc.2018.202

Probing hyperbolic polaritons using infrared attenuated total reflectance micro-spectroscopy

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Hyperbolic polariton modes are highly appealing for a broad range of applications in nanophotonics, including surfaced enhanced sensing, sub-diffractional imaging, and reconfigurable metasurfaces. Here we show that attenuated total reflectance (ATR) micro-spectroscopy using standard spectroscopic tools can launch hyperbolic polaritons in a Kretschmann–Raether configuration. We measure multiple hyperbolic and dielectric modes within the naturally hyperbolic material hexagonal boron nitride as a function of different isotopic enrichments and flake thickness. This overcomes the technical challenges of measurement approaches based on nanostructuring, or scattering scanning near-field optical microscopy. Ultimately, our ATR approach allows us to compare the optical properties of small-scale materials prepared by different techniques systematically. DOI:10.1557/mrc.2018.205

PC-12 cells adhesion and differentiation on carbon aerogel scaffolds

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Electrically conducting substrates have shown much promise as neuronal scaffolds and in other biologic and biomedical applications where a smart and electrically interactive material is needed. Most materials that are inherently conducting are not suitable for biomedical applications and lack biocompatibility or biostability. On the other hand, biologically stable and compatible materials must first be manipulated, modified, and treated in order to impart the necessary electrical conductivity to the material. Here, the authors have investigated the response of PC-12 cells to two types of conducting carbon-based aerogels with different surface roughness. Results show that carbon-based aerogels support cell adhesion, proliferation, and neurite extension. The effects of surface roughness have also been investigated. DOI:10.1557/mrc.2018.206

Zinc oxide nanorod array as an inhibitory biointerface

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One-dimensional zinc oxide (ZnO) nanostructure arrays show unique semiconducting, piezoelectric, and wetting properties, and how they interact with cells is critical for their biomedical applications. In this work, we prepare ZnO nanorod arrays (ZnO NRAs) and study their interactions with neonatal rat cardiomyocytes either as a substrate or patch. We find that ZnO NRAs can (1) inhibit cell adhesion and spreading as a substrate and (2) selectively kill underneath cells as a patch. We further identify surface nanomorphology as the dominant factor responsible for the inhibitory effect. These discoveries suggest potential application of ZnO NRAs as a cell inhibitory biointerface. DOI:10.1557/mrc.2018.190

Vortex glass-liquid transition and activated flux motion in an epitaxial, superconducting NdFeAs(O,F) thin film

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An epitaxial NdFeAs(O,F) thin film of 90 nm thickness grown by molecular beam epitaxy on a MgO single crystal with T = 44.2 K has been investigated regarding a possible vortex glass–liquid transition. The voltage–current characteristics show excellent scalability according to the vortex-glass model, with a static critical exponent ν of around 1.35 and a temperature-dependent dynamic exponent z increasing from 7.8 to 9.0 for the investigated temperature range. The large and non-constant z values are discussed in the frame of 3D vortex glass, thermally activated flux motion, and inhomogeneity broadening. DOI:10.1557/mrc.2018.207

Investigation into boron nitride nanoparticle effects on thermal properties of calcium chloride hexahydrate ($CaCl_2 \cdot 6H_2O$) as a phase change material

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This paper presents thermal properties' characterization of calcium chloride hexahydrate as a phase change material (PCM) combined with boron nitride nanoparticles (BNNPs), leading to efficient thermal management. BNNPs have high-thermal conductivity up to 200 W/m K. Therefore, the thermal conductivity of PCM could be remarkably enhanced by adding BNNPs to improve the heat transfer performance. In this study, 0.5 wt% of BNNPs were dispersed in the molten PCM. It has been found that the BNNPs could enhance the thermal conductivity of PCM by 71.9%, while reduce the latent heat of fusion and specific heat of PCM by 11.1% and 60.9%, respectively. DOI:10.1557/mrc.2018.210

Developing a novel continuum model of static and dynamic contact angles in a case study of a water droplet on micro-patterned hybrid substrates

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Modeling static and dynamic contact angles is a great challenge in studying wetting and de-wetting. We propose a new slip boundary model based on the Navier–Stokes equations, and establish a realistic continuum approach to simulate the contact line dynamics in 3D. To validate our model, a water droplet interacting with micrometer-sized patterns of a hybrid hydrophobic/-philic surface is studied numerically and compared with experimental measurements. Good agreement has been observed with four pillar spacings in the static, receding, and advancing modes. Moreover, details of the droplet–surface interaction are revealed, for example, penetrations, sagging, local, and global contact angles. DOI:10.1557/mrc.2018.215

Lattice effect in Mie-resonant dielectric nanoparticle array under oblique light incidence

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Ultra-thin optical structures, known as metasurfaces, have shown promising light controlling capability at the nanoscale. In this paper, we study their particular case, a periodic array of high-refractive-index nanoparticles with electric and magnetic resonances. The main result of the work is a numerical demonstration that the lattice effect in the periodic arrangement of nanoparticles changes the resonance position even if the resonances are above the diffraction wavelength

(Rayleigh anomaly). We show that the disk resonance changes can be achieved not only by varying periods of the array under normal light incidence but also by changing the incident angle. DOI:10.1557/mrc.2018.216

Optimizing thermal conduction in bulk polycrystalline $SrTiO_{3-\delta}$ ceramics via oxygen non-stoichiometry

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While $SrTiO_3$ exhibits promising electronic transport properties, its high thermal conductivity (κ) is detrimental for its use as a thermoelectric material. Here, we investigate the influence of oxygen non-stoichiometry on κ in bulk $SrTiO_3$ ceramics. A significant reduction in κ was achieved in oxygen deficient $SrTiO_{3-\delta}$, owing to the presence of oxygen vacancies that act as phonon scattering centers. Upon oxidation of $SrTiO_{3-\delta}$, the κ of pristine $SrTiO_3$ was recovered, suggesting that oxygen vacancies were indeed responsible for the reduction in κ. Raman spectroscopy was used as an independent tool to confirm the reduction of oxygen vacancies in $SrTiO_{3-\delta}$ upon oxidation. DOI:10.1557/mrc.2018.220

Hard-switching reliability studies of 1200 V vertical GaN PiN diodes

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We report on reliability testing of vertical GaN (v-GaN) devices under continuous switching conditions of 500, 750, and 1000 V. Using a modified double-pulse test circuit, we evaluate 1200 V-rated v-GaN PiN diodes fabricated by Avogy. Forward current–voltage characteristics do not change over the stress period. Under the reverse bias, the devices exhibit an initial rise in leakage current, followed by a slower rate of increase with further stress. The leakage recovers after a day's relaxation, which suggests that trapping of carriers in deep states is responsible. Overall, we found the devices to be robust over the range of conditions tested. DOI:10.1557/mrc.2018.204

Characterization of interface thermal resistance between graphene and Cu film by using a micropipette thermography technique

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We have investigated interfacial thermal resistance (ITR) between single-layer graphene and Cu substrate by using both experimental and numerical methods. For experiments, the micropipette sensing technique was utilized to measure the thermal conductivity of suspended graphene and temperature profile of supported graphene on a Cu film subjected to heating with a point source continuous wave laser. The thermal conductivity of suspended single-layer graphene was measured to be 3492 ± 453 W/m°C from measurements of temperature profile on the suspended graphene. This intrinsic graphene thermal conductivity and the finite element method integrated with a multi-parameter fitting technique were used to estimate ITR between graphene and the Cu film. In the multi-parameter fitting technique, the simulated temperature profile is compared with the experimentally measured temperature profile on the supported graphene surface, and the best-fitted parameters, including thermal interface resistance, was obtained. The estimated interface thermal resistance between single graphene and Cu substrate is 2.3×10^{-7} m^2 K/W, and the difference between experiment and simulation result during multi-parameter fitting is 6.9%. DOI:10.1557/mrc.2018.219

Crack propagation in porous polymer sheets with different pore sizes

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Physical understanding of crack propagation is a fundamental issue in industry. In the literature, crack velocities of polymer materials are strongly dependent on their visco-elastic properties and energy release rates. Recently, numerical and theoretical studies have proposed that structural sizes in polymers also influence crack propagation. Here, using polymer sheets with similar visco-elastic properties but with different pore sizes, we vary explicitly the representative structural size and examine the effect of the size on crack propagation. Findings in this work help us to understand crack propagation in polymer materials and bio-inspired materials that have porous structures. DOI:10.1557/mrc.2018.222