PG4B : 나노 융합 세라믹스

PG4B-1 | Size-Dependent Blue Emission of Graphene Quantum Dots

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Graphene Quantum Dots (GQDs) have garnered significant attention for their intriguing size-dependent properties in optical characteristics. We investigate the size-dependent blue-emission properties of GQDs within the subdomain range of 5nm, 2nm, and 1nm and examine the trend of intensified blue-emission as GQD size decreases, displaying their potential applications in nanophotonics, optoelectronics. We analysed the fabricated GQDs, using SEM and TEM to determine their sizes. Furthermore, utilizing photoluminescence (PL) and ultraviolet-visible spectroscopy (UV-vis), we observed enhancements in photoluminescence quantum yield (PLQY) and a blue-shift phenomenon as GQD size decreased. These highlight the effectiveness of our novel GQD production method, which yields GQDs at a faster rate and results in higher PLQY. Furthermore, we emphasise on harnessing exceptional blue-emission properties of 1nm GQDs and functionalizing them through various approaches diode technology integration. This research contributes to our understanding of size-dependent properties of GQDs and allows further advancements in GQD-based diode research.

PG4B-2 | 이온층 레이어 에피택시법으로 합성된 $NiO/Ni(OH)^2$ 나노시트 특성 평가 및 안정성 향상 연구

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2차원 나노 물질은 벌크 물질에 비해 높은 비표면적을 가지고 있으며 모양과 크기 그리고 두께에 따라 새로운 물리적, 기계적, 화학적 특성을 갖는 물질이다. 따라서 최근 나노 물질의 특성을 조절하여 전자, 에너지 저장, 센서 등 다양한 분야에서 기존 소재를 대체하거나 보완하기 위한 연구가 활발히 진행되고 있다. 나노 차원의 물질을 만들기 위한 방법 중 하나인 Bottom-up은 원하는 구조를 정밀하게 제어할 수 있지만 합성 과정이 복잡하며 시간이 오래 걸린다는 단점이 있다. 본 연구에서는 최근 개발된 Bottom-up 방식의 이온층 레이어 에피택시법을 통해 기존 합성법에 비해 상대적으로 간단하게 나노 시트를 합성하였다. 또한 나노 시트의 합성을 위해 사용되는 surfantant 함량을 조절함으로써 나노 시트의 모양과 두께를 제어하여 안정적인 나노 시트를 형성시켰다. 제작된 $NiO/Ni(OH)^2$ 나노 시트는 주사전자현미경(scanning electron microscopy, SEM)을 통해 형상을 확인하였고, XPS(X-ray photoelectron spectroscopy)와 XRD(X-ray diffraction)을 통해 결정학적 특성 및 화학적 결합을 규명하였다. 위의 자세한 내용은 2023년 한국세라믹학회 추계학술대회에서 자세하게 논의될 것이다.

PG4B-3 | 반도체 공정 기반 바이오센싱용 SERS 칩 제조

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Surface-enhanced Raman spectroscopy (SERS) is a powerful analytical technique with applications in various fields, including chemistry, biology, and materials science. One crucial aspect of SERS is the design and fabrication of high-performance substrates that can enhance the Raman signal from analytes. In this study, we explore the use of 300 mm-wafer-scale ArF immersion lithography for fabricating 40nm patterning structures as SERS substrates, and the nanostructured substrates can be employed in various applications through the multi-component thin film process. The 40nm patterning structures offer several advantages for SERS applications. Their nanoscale dimensions covered with plasmonic metal species allow for the confinement of electromagnetic fields, leading to significant enhancement of Raman signals. Additionally, the precise thickness control of covered metal on nanopattern structure enables the tuning of SERS enhancement for specific analytes. We present the semiconductor technology-based fabrication process of these substrates and evaluate their performance in enhancing Raman signals. Through comprehensive characterization and testing, we demonstrate that the semiconductor nanostructured patterning process provides the effective scaffolds for excellent SERS enhancement properties, making them promising candidates for various analytical and sensing applications.

PG4B-4 | Large-Area Fabrication of 3D Nanostructures using Proximity-field Nanopatterning (PnP)

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It has been an engineering pursuit to develop fast and facile technology for fabricating sub-micron-ordered structures in a larger area. Among the many fabrication techniques, Proximity-field Nanopatterning (PnP) using conformal phase masks, offers advantages of high productivity and spatial resolution. The fundamental optics of PnP consisting of the period and relief depth of the phase ask, and refractive index of the base materials affect the resultant resolution and topology of the three-dimensional (3D) nanostructures. In addition, the progress of PnP enables the fabrication

of a wide variety of functional nanostructures combined with material conversion techniques such as electroplating, and atomic layer deposition (ALD). Inch-scale 3D nanostructures have demonstrated unprecedented performance in various applications such as energy, catalysis, and electronic devices. In the presentation, we briefly introduce the overall history of PnP and its resultant achievements.

PG4B-5 | 3D Bimetallic Air-Cathodes for Li-air Batteries via Proximity-field Nanopatterning

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Lithium-air batteries have been anticipated as promising high-energy-density energy storage systems. Although they possess the highest theoretical energy-density, their practical application is plagued by low energy efficiency, small capacity, and the short cycle life due to poor reaction kinetics revolving around the cathode. To solve this problem, an efficient catalyst is required for both the oxygen reduction reaction (ORR) and the oxygen generation reaction (OER). Therefore, fabricating bimetallic 3D Ni/Pd air-cathodes we demonstrate heightened electrochemical performances compared to monometallic 3D Ni air-cathodes. By using Proximity-field nanopatterning (PnP), we can fabricate a polymer template for material conversion via electroplating (EP). We obtain 3D Ni structures and decorate them with Pd, both using EP, to fabricate 3D bimetallic air-cathodes. The integration of these bimetallic 3D nanostructures for electrode fabrication maximized the active surface area and heightened the OER and ORR performance within the electrode, therefore enhancing battery performance.

PG4B-6 | Thermally Conductive Silicone Adhesives with Boron Nitrides for Flexible Thermal Interface Materials

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Due to high integration of devices, a large amount of heat is generated, which may cause malfunctions or performance degradation. Polymers with good processability and mechanical properties are emerging as heat dissipation materials. However, polymers have a low thermal conductivity (~0.2 W/mK). The most effective way to address this issue is to incorporate fillers with high thermal conductive. Boron nitride is a good choice due to its high thermal stability and conductivity (400-1000 W/mK). In this study, we demonstrate thermally conductive silicone adhesives hybridized with well-dispersed boron nitrides. For well-dispersion in silicone matrix, boron nitrides are functionalized with organic molecules via ball milling process. The mechanical and thermal properties of the thermally conductive silicone adhesives were systematically analyzed.

PG4B-7 | 유무기하이브리드 코팅제의 수지와 표면개질된 실리카졸과의 혼화성 연구

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본 연구에서는 폴리카보네이트(PC)의 낮은 내마모성과 내화학성을 해결하기 위하여 강도가 높은 실리카와 투과도 및 수지와의 혼화성을 높인 유무기 하이브리드 코팅에 대한 연구를 진행하였다. 실란 종류에 따라 표면개질된 실리카졸은 표면 하이드록사이드 개수를 측정하기 위하여 산-염기 적정법을 이용하였으며, FT-IR 및 TGA 등으로 표면개질된 정도를 비교 분석하였다. 아크릴계열 수지와 혼합된 유무기 하이브리드 코팅액은 PC 표면에 코팅된 도막은 실리카졸의 크기, 실리카/수지의 함량, 표면개질된 실리카의 종류, 표면개질양에 따른 실리카 등과 수지와의 혼화성에 따라 코팅 특성은 투과도, 부착력, 경도 등으로 비교 평가하였다.

PG4B-8 | 열분해 온도가 ceramic/nickel 복합체의 HER 촉매 활성에 미치는 영향

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Ceramics serve as common support materials for enhancing the catalytic performance of metal catalysts. However, the integration of ceramics and metals is intricate due to the necessity of additional additives like binders. Additionally, achieving uniform distribution of catalysts within ceramics poses a challenge. To overcome these issues, this research employs preceramic polymers as precursors for ceramics. By blending preceramic polymers with nickelocene and subjecting them to simple pyrolysis, ceramic/nickel composites are formed. These composites exhibit evenly dispersed nanometer-sized nickel particles or nickel silicide. The microstructure of the resulting ceramic/nickel composites, synthesized at varying pyrolysis temperatures, was examined using analytical techniques including BET, XRD, TEM, and ICP-AES. Furthermore, the catalytic performance of these composites in the hydrogen evolution reaction was assessed to investigate the impact of pyrolysis temperature.

PG4B-9 | Synthesis of amorphous cobalt hydroxide nanosheets

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Two-dimensional nanosheets attract attention as a nanostructure that maximize electrochemical performance due to their unique advantages of large specific surface area and large exposure to active sites. We have synthesized amorphous cobalt hydroxide nanosheets with a thickness of less than 1.5 nm. The nanosheets laterally grown have been converted into crystalline cobalt oxides through simple heat treatment. The morphological results have been analyzed by scanning electron microscopy and atomic force microscopy. The chemical information and structural characteristics of the nanosheets have been investigated using X-ray photoelectron spectroscopy, and the crystallinity of nanosheets were confirmed through transmission electron microscopy. Furthermore, their electrochemical properties have been acquired. This study provides a comprehensive overview of the characteristics and information regarding cobalt hydroxide.

PG4B-10 | A general approach to simple fabrication of flower-like ZnO

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ZnO nanosheets having nano-sized grain distribution, high mesoporosity, and ultrathin thickness have attracted much attention due to their intriguing properties, such as high surface-to-volume ratio and superior chemical activities. Currently, various synthesis methods capable of making two dimensional structures have been reported, and among them, the surfactant-assisted method has been reported as an interesting method for realizing a nanosheet structure at the water-air interface without regard to the crystal structure of the material. This method can control the composition of metal cations as well as the morphology of nanosheets. Using this method, dominant flower-like ZnO has been synthesized by controlling the atmosphere and reaction time inside the container where the material is synthesized. Because of the abundant reaction sites of the flower-like ZnO, well-developed structures exhibit electrochemical properties and gas accessibility. This study can contribute to the realization of flower-like structured metal oxide nanosheet series that can be applied to various research fields.

PG4B-11 | Comparison of Luminescence properties of carbon dots derived o-phenylenediamine and o-toluidine

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Phenylenediamine based carbon dots (CDs) have been studied as a luminescent material in next generation, due to their variable luminescence, high bio-compatible property, easy synthesis, hydrophilic characteristics, and abundant source. Although the o-phenylenediamine based carbon dots exhibit yellow luminescence under UV excitation, their excitation independent luminescence and poor chemical stability can inhibit further application in LED, anti-counterfeiting, bio-imaging, etc. To solve these problems, the utilization of acid in the synthesis process have been suggested. The high quantity of H^+ allows the two-dimensional growth of the CDs, which allows enhanced chemical stability and red luminescence. However, these carbon dots possess poor applicability in UV and blue based LEDs due to their dominant excitation is in green region. In order to solve these problem, utilization of o-toluidine can be solution of these problem to reduce the nitrogen contents. In this study, the CDs derived from o-toluidine and o-phenylenediamine were synthesized by using a hydrothermal method. To investigate their characteristics, the structural, morphological, luminescent properties of both CDs was analyzed and compared.

PG4B-12 | Realizing swift chromatic transitions through Molecular printing

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Reflective-type display using thermochromic materials offers several advantages over the conventional optoelectronic technology: a passive circuit element-driven simplified device layout, cost-effectiveness, and clear visibility. An Inherent challenge of chromic displays is slow color transition, which results from the mass-dependent characteristic of chromic inks. A large mass of the thermochormic ink has a large heat capacity requiring more energy to induce color switching. A molecular printing using polymer pen array technique that can reduce the mass of the delivered ink, may offer the ability to effectively control the switching time in

a spatially controlled manner. Here, we demonstrate a method for molecular printing of a thermochromic ink with a low heat capacity, enabling an unprecedented, fast color switching without any optoelectronic elements. Molecularly printed ink is patterned on fabricated microheaters that induce transient local heat generation, facilitating local heating and cooling processes. Depending on the concentration of the thermochromic ink, i.e., the number of microcapsuled dyes in the form of a monolayer resulting in a low heat capacity, the chroma of the patterned ink could be increased. Using this technique, the thermochromic ink could be printed over centimeter scales, with CMYK (cyan-magenta-yellow-black) colors at a color-switching rate of 20–500 ms, to be integrated into the thermochromic device prototype for potential display applications.

PG4B-13 | Barium molybdate up-conversion phosphors with potential application in optical temperature sensing

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Barium molybdate up-conversion (UC) phosphor was synthesized by co-precipitation and calcination of the precursor at 800 ◦C. The main peak (112) plane for the synthesized phosphor was strongly detected in the XRD pattern and had a tetragonal structure. The doping of rare-earth ions affected the crystal lattice by shifting the main peak, decreasing the lattice constant, and shifting the position of the Raman signal. The synthesized upconverted phosphor exhibited strong green signals at 530 and 553 nm and weak red signals at 657 nm when excited at 980 nm. The green light emission intensity of the UC phosphor increased as the pump power of the laser increased due to the two-photon effect. The synthesized upconverted phosphor was prepared as a pellet and flexible composite. Thermal quenching led to a decrease in luminescence intensity as the temperature increased, which means that the phosphor can be applied to optical temperature sensing.

PG4B-14 | Soft Photomask-enabled Non-Planar Nanoscale Contact Photolithography in the Near-Field Regime

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Photolithography continues to be the prevailing microfabrication technology as long as it continues to meet the resolution and yields demands at a cost that makes it economically viable. Among these requirements, the fundamental resolution challenge is diffraction of light at the edge of an opaque feature on the mask as the light passes through an adjacent clear area, which has been addressed by ‘optical trick’ with complex optics, but eventually compromises the cost-effectiveness. Here, we present an unprecedented near-field optical printing approach that uses chromium patterns embedded in elastomer for near-field operation, which routinely generates sub-diffraction patterns using existing hardware and prevailing 400-nm light source. Conformal contact with a substrate using an elastomeric photomask overcomes the diffraction issues of light-based printing systems, and also eliminates a depth-of-focus issue, thereby enabling photolithography for non-planar substrate which is important for future wearable electronics. Our method secures high resolution, parallel-writing and cost-effective characteristics of photolithography and provides routine patterning process for non-planar substrate, which should be widely used in academic and industrial production for electronic, optical and metamaterial applications. but secures parallel-writing and cost-effective characteristics, which should be widely used in academic and industrial production for electronic, optical and metamaterial applications.

PG4B-15 | Combined Patterning of Nanotransfer Printing and Laser Micromachining

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High-resolution patterning technologies are required to develop various next-generation electrical/electronic devices such as battery electrodes, high-sensitivity sensors and memory devices. In particular, nanotransfer printing (nTP) has attracted much attention due to its simple process, cost-effectiveness and compatibility with other nano-fabrication methods. Here, we introduce a novel and useful method to create nano-to-micro-pattern structures by employing a combined patterning process of nTP and laser micromachining. We show that fabrication of periodic functional patterns on the various surfaces, such as transparent/flexible materials and rigid metallic substrates. At first, we present how to obtain

nano-/micro-scale pattern structures on the colorless polyimide (CPI) film by nTP process. Then, we show pattern formation of multiscale nano-in-micro-in-millimeter (NMM) structures by laser micromachining process under the optimized conditions. Furthermore, we demonstrate how to generate holographic patterns with optically colorful properties of rainbow light by patterning the critical dimension of the patterned structures. We expect that this combined patterning process to contribute to effectively fabricate various future devices to induce holographic properties.

PG4B-16 | Ultrathin large-area 2D holey metal nanosheets as highly efficient electrocatalysts

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Elemental metal nanostructures have evoked a great deal of research efforts because of their unique physicochemical properties and valuable functionalities. Here we report a novel synthetic route to ultrathin 2D holey Ru nanosheets with atomic-level thickness and surface holes via the finely-controlled thermal reduction of exfoliated RuO_2 monolayer at elevated temperature. The obtained Ru nanosheets show extremely high morphological anisotropy with ultrathin thickness of ~1.0 nm, huge lateral dimension with micrometer size, and controllable size of surface holes. This is the first example of ultrathin holey metal nanosheets with extremely high morphological anisotropy. The alteration of reduction condition enables to optimize the electrocatalyst performance of Ru metal nanosheets via the fine-tuning of defect structure. The obtained holey Ru nanosheets deliver higher electrocatalytic activity for hydrogen evolution reaction (HER) in 1.0 KOH electrolyte than those of Pt/C and bulk Ru metal. The beneficial effect of holey nanosheet formation on the HER electrocatalytic activity can be ascribed to the creation of crystal vacancies, the provision of many surface sites, and the improvement of mass transport.

PG4B-17 | Ligand Crosslinking Strategy for Efficient Quantum Dot Light-emitting Diodes via Thiol-ene Click Chemistry

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Patterning of colloidal quantum dots are essential to realize the complex device architectures in commercial applications. Direct optical patterning by manipulating the surface ligands allows the high-resolution patterning of quantum dots. Here, we report the ligand crosslinking strategy based on thiol-ene click chemistry. The thiol molecules generate free radicals upon exposure to UV light, leading to a ligand crosslinking. Selective area exposure of UV enables the micro-scale direct photopatterning of nanocrystals including quantum dots and metal oxide nanocrystals. The effect of thiol-ene crosslinking on photoluminescence and electroluminescence properties of solid-state quantum dots is discussed. Light-emitting diodes using crosslinked InP based quantum dot layer exhibit the 23.04 cd/A of peak current efficiency which is 58% higher than typical devices. The improvement of current efficiency is also demonstrated in CdSe based light-emitting diodes.

PG4B-18 | 비행 시간 질량 분석법을 이용한 CF_4 혼합 플라즈마 거동 분석 및 세라믹 재료의 고온 플라즈마 내식성 평가방법 개발

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4차 산업혁명으로 인해 반도체 수요가 급격히 증가하며 고집적, 고성능, 저전력의 반도체 소자에 대한 요구사항이 높아지고 있다. 이런 요구사항을 충족하고 기존 평면상의 반도체 소자 및 회로 집적도의 한계를 극복하기 위해 복잡한 적층 구조를 정보 저장소자와 논리소자에 적용하는 방법이 주목받고 있다. 그러나 이런 복잡한 구조를 구현하기 위한 플라즈마 식각 공정은 더욱 고도화되어 더 높은 식각률, 종횡비, 선택비를 확보하기 위하여 다양한 시도가 이루어지고 있다. 특히 고온 플라즈마는 높은 에너지 밀도와 활성도를 가지고 있기 때문에 다양한 플라즈마 공정에서 활용될 수 있다. 그러나 고온의 식각 가스 및 플라즈마 노출에 의해 장비 내 세라믹 히터를 비롯한 부품의 부식 역시 활발하게 발생한다는 문제가 있다. Y계 Mg계 세라믹 소재 등 내플라즈마 특성을 가진 소재의 개발이 이루어지고 있지만, 특히 높은 온도에서 플라즈마를 제어하는 기술과 고온 조건에서 부식성 가스에 의한 내플라즈마 특성의 평가 기술의 개발은 더딘 실정이다. 본 연구에서는 최대 650℃의 온도에서 CF4 혼합 플라즈마를 발생시키고, 비행 시간 질량 분석법(Time of Flight Mass Spectrometer)을 이용하여 기체 부산물을 수집하여 온도에 따른 플라즈마 반응을 분석하였다. 또한 다양한 종류의 세라믹 소재를 대상으로 플라즈마 환경에 따른 소재 식각 모니터링 시스템을 구축하고 이를 통해 내플라즈마 특성을 효율적으로 평가할 수 있는 방법을 제시하였다. 이러한 연구 결과는 고온 플라즈마를 이해하고 공정에 적용하는 방법을 제공하고, 반도체 공정 챔버 내 내플라즈마 세라믹 부품의 수명과 안정성을 개선하는데 기여할 것이다.

PG4B-19 | Chemically and Electronically Active Metal Ions on InAs Quantum Dots for Infrared Detectors

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Colloidal InAs quantum dots (QDs) are emerging candidates for NIR-SWIR optoelectronic applications because of their excellent electrical and optical properties. However, the syntheses of InAs QDs, which demand strongly reducing atmospheres or highly reactive precursors, are difficult because of their highly covalent bonding and lack of Group 15 precursors.[1] While the coreduction method with commercially available arsenic precursors enables facile syntheses of InAs QDs, it results in broad size distributions requiring subsequent size-selection processes. In this study, we introduced zinc ions in the form of coordination complexes during coreduction of the indium and arsenic precursors. The Zn ions chemically passivated the surfaces for the InAs QDs, narrowed the size distribution, and removed surface defects. When the InAs QDs were integrated into infrared photodiodes as IR absorbers, the surface-attached Zn ions electrically modulated the energy level and carrier concentration. Infrared photodiodes with the InAs:Zn QD layers exhibited dark currents and photoresponses that were two orders of magnitude lower and approximately twice as fast, respectively, as those seen for bare InAs QDs.

PG4B-20 | 정렬된 3차원 나노구조를 이용한 고성능 마이크로 가스 농축기 제작

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A sensor system coupled with micro-gas chromatography (μ-GC) has been regarded as a promising approach for practical on-site gas detection, which can effectively detect specific target gases by separating analytes within a mixture. A micro-preconcentrator (μ-PC) is one of the key components to enhance accurate gas detection when their concentration is low. However, discontinuous and disordered pore topology of the traditional μ-PCs induces reduced gas flow and inactive surfaces. In this study, we introduce a new type of μ-PC system utilizing ordered three-dimensional (3D) thin-shell oxide adsorbents. The 3D Al_2O_3 adsorbents are fabricated using Proximity-field nanopatterning (PnP) and atomic layer deposition (ALD). The fabricated 3D Al2O3/Tenax adsorbent increase the preconcentration factors (PFs) for various gases, achieving PFs of 6.94, 25.9, and 145 for benzene, toluene, and xylene, respectively. Additionally, the PFs per unit volume of each gas are enhanced by 44 /μL, 162 /μL, and 911 /μL for benzene, toluene, and xylene, respectively. This substantial improvement in PF per unit volume provides a promising feasibility of the next-generation μ-PC design for high-performance μ-GC systems.