

### SW13 : 기능성 세라믹 소재 혁신 R&D 전문인력양성

#### SW13-1 | 다양한 유기 리간드를 가진 SnO<sub>2</sub> 나노입자를 이용한 양자점 발광 다이오드의 전하 균형 향상 연구

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Colloidal quantum dots (QDs) are semiconductor particles with a nanometer size that can tune the emission wavelength by controlling the size and shape through the quantum confinement effect. QDs also exhibit excellent color gamut due to their narrow half-width emission wavelength. [1] These unique optical and electrical properties of QDs have propelled quantum dots light-emitting diodes (QLEDs), using QDs as an emission layer, to garner significant attention as a next-generation display technology. ZnO nanoparticles (NPs), which are mainly studied as the electron transport layer (ETL) of QLEDs, have the advantage that their energy band is well matched with that of QDs and solution processing is possible. However, the ZnO NPs solution is unstable because ZnO NPs are easily agglomerate in organic solvents at room temperature. Recently, SnO<sub>2</sub> NPs are considered as one of alternate inorganic materials for ETL. However, only limited studies have been reported for SnO<sub>2</sub> based QLEDs. In this study, QLEDs with an inverted structure were fabricated using SnO<sub>2</sub> NPs with various organic ligands. Different lengths of organic ligands are expected to modulate the electron mobility and solubility. Inverted structured QLEDs using SnO<sub>2</sub> NPs showed the maximum luminance of 79,706 cd/m<sup>2</sup> and the maximum current efficiency of 21.16 cd/A. This high-efficiency devices resulted from a balanced charge transport. Through this study, we suggest that SnO<sub>2</sub> NPs are a promising ETL materials in inverted structure QLEDs. The stability of device with SnO<sub>2</sub> NPs will be studied for the practical display application.

#### SW13-2 | 물분해의 효율적인 전기촉매를 위한 Ni-Fe-S/Nickel foam의 윈스텝 전기화학 합성

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Hydrogen, a sustainable and environment-friendly energy source, has attracted great interest to alleviate the global energy crisis and environmental pollution. Electrolytic water splitting using energy from renewable sources is regarded as the key technology for generating an ample amount of pure hydrogen gas. Ni and Fe are earth-abundant and cost-effective non-noble metals, and their different alloy composition enables various

nanostructures and electrical properties, which have promoted the utilization of these alloys as the catalysts of water electrolysis. It has been reported that layered-double hydroxide (LDH) structure and new compounds synthesized by adding other elements can reduce the overpotentials of oxygen evolution reaction (OER) and hydrogen evolution reaction (HER) that makeup water electrolysis. Recently, high electrical conductivity and rich-redox reactions of transition metal chalcogenides have been investigated, and studies have reported that heterogeneous transition metal sulfides can provide abundant active sites and boost ion/electron transport pathways. In this study, the effect of sulfur doping on the performance of water electrolysis is explored. Ni-Fe-S catalysts are electrochemically synthesized on Nickel Foam (NF) substrates by adding thiourea to a previously reported precursor solution of Ni-Fe. Enhanced electrocatalytic performance was confirmed when the Ni-Fe-S@NF catalyst was synthesized by adding a chalcogen element. The OER performances of the electrocatalysts prepared under various conditions were characterized through Linear sweep voltammetry (LSV), Tafel slope, and Electrochemical impedance spectroscopy (EIS). As a result, the Ni-Fe-S@NF catalyst with an optimized component required the overpotential of 362 mV to deliver a current density of 100 mAcm<sup>-2</sup> and the Tafel slope of the catalyst is only 62.19 mV/dec which is lower than those of other catalysts. The obtained R<sub>ct</sub> of Ni-Fe-S@NF is 0.502 Ω, which has a smaller diameter of a semicircle than those of other catalysts, suggesting better conductivity. Moreover, Ni-Fe-S@NF electrocatalysts exhibit unique 2D layered nanosheet structures with abundant active sites, which could be supported by theory calculations. Therefore, we believe that this simple and convenient synthetic procedure will lead to the production of high-performance electrocatalysts in a manageable and green technique, which can be widely applicable in hydrogen energy and environmental fields.

#### SW13-3 | Preparation of maghemite-nitriilotriacetic acid with amino and carboxyl functional groups attached

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Maghemite ( $\gamma$ -Fe<sub>2</sub>O<sub>3</sub>) with strong magnetism is used in various fields due to its chemical stability and low cost. It is also being applied to biofields such as cell separation and regenerative medicine, but the stability of biological applications has not been sufficiently proven, so additional research is needed. In this study, surface

modification was performed on  $\gamma$ -Fe<sub>2</sub>O<sub>3</sub> particles using nitrilotriacetic acid (NTA), which is widely used for biological applications. Amine functionalization was applied to attach a sufficient amount of NTA to the surface. The adhesion tendency due to the difference in surface bonding structure was compared using (3-aminopropyl)triethoxysilane (APTES), a silane precursor, and polyethyleneimine (PEI), a polymer precursor. Then, carboxyl functionalization was performed using glutaraldehyde to link between the NH<sub>2</sub> and amine functional groups of NTA. Finally, after attaching the NTA, Zeta potential, TEM, and FT-IR were measured to compare and analyze the adhesion tendency and electrical and magnetic properties.

#### SW13-4 | Effect of Na<sup>+</sup> substitution on microwave dielectric properties of Mg<sub>2</sub>SiO<sub>4</sub> ceramics

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Microwave dielectric properties of Mg<sub>2-x</sub>Na<sub>2x</sub>SiO<sub>4</sub> (0.01 ≤ x ≤ 0.04) ceramics were investigated as a function of Na<sup>+</sup> substitution (x). Structural characteristics of Mg<sub>2-x</sub>Na<sub>2x</sub>SiO<sub>4</sub> ceramics were quantitatively evaluated by the Rietveld refinement method from the X-ray diffraction (XRD) data. Na<sup>+</sup> substitution for Mg<sup>2+</sup> could decrease the sintering temperature of Mg<sub>2</sub>SiO<sub>4</sub> ceramics from 1525°C to 1100°C due to the low melting temperature (=851°C) of Na<sub>2</sub>CO<sub>3</sub>. Single phase with forsterite structure was confirmed up to x=0.03, and then secondary phase of Na<sub>2</sub>MgSiO<sub>4</sub> was observed upon substitution. The dielectric constant (K) of the specimens increased with Na<sup>+</sup> substitution (x) due to the higher dielectric polarizability of Na<sup>+</sup> (1.80Å<sup>3</sup>) than that of Mg<sup>2+</sup> (1.32Å<sup>3</sup>). With the increase of Na<sup>+</sup> substitution (x), microstructure of the specimens was not changed remarkably. Highest quality factor (Qf=80,200GHz) was obtained for the specimens of Mg<sub>1.97</sub>Na<sub>0.06</sub>SiO<sub>4</sub> (x=0.03) sintered at 1100°C for 3h due to the highest degree of covalency and bond strength of MgO<sub>6</sub>.

#### SW13-5 | Novel Synthesis of Core-Shell Structure $\gamma$ -Fe<sub>2</sub>O<sub>3</sub>@SiO<sub>2</sub> Nanoparticles Via Sodium Silicate Precursor for Plasmid DNA Purification

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Superparamagnetic nanoparticles hold promise for applications in the field of bioindustries. Especially Fe<sub>3</sub>O<sub>4</sub> is commonly used, but its narrow area for Fe<sub>3</sub>O<sub>4</sub> synthesis,

as indicated by the Fe-O phase diagram, complicates large-scale production. Conversely,  $\gamma$ -Fe<sub>2</sub>O<sub>3</sub>, another superparamagnetic material, exhibits high magnetization and ease of production at scale. However, its magnetization hinders effective colloidal dispersion. To address this, core-shell structure with a high surface charge SiO<sub>2</sub> coating, achieved through numerous hydroxyl groups, was introduced. In contrast to the costly limitations of using TEOS, this study employs Na<sub>2</sub>SiO<sub>3</sub> for  $\gamma$ -Fe<sub>2</sub>O<sub>3</sub>@SiO<sub>2</sub> core-shell particle synthesis. This structure enhances DNA purification efficiency by capitalizing on electrostatic interactions among hydroxyl groups, salts, and DNA molecules. In this study,  $\gamma$ -Fe<sub>2</sub>O<sub>3</sub> nanoparticles are pre-treated with acid or base solutions, and then coated with Na<sub>2</sub>SiO<sub>3</sub>. SiO<sub>2</sub> coating thickness and surface charge are analyzed according to the pre-treatment solution's pH. Finally, DNA purification properties of the prepared particles are evaluated.

#### SW13-6 | Complex Substitutional Effect of Zn<sup>2+</sup> and (Mg<sub>1/3</sub>Ta<sub>2/3</sub>)<sup>4+</sup> on Microwave Dielectric Properties of MgTiO<sub>3</sub> ceramics

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Microwave dielectric properties of (Mg<sub>1-x</sub>Zn<sub>x</sub>)(Ti<sub>0.95</sub>(Mg<sub>1/3</sub>Ta<sub>2/3</sub>)<sub>0.05</sub>)O<sub>3</sub> (MZTMT) (0.00 ≤ x ≤ 0.05) ceramics were investigated based on the crystal structural characteristics. The structural characteristics of MZTMT ceramics were quantitatively evaluated by Rietveld refinement method from X-ray diffraction patterns. Complete solid solutions for the entire range of MZTMT ceramics were obtained with the single phase of ilmenite structure by controlling the relative ratio of Mg to Ti. Relative density of all the specimens was higher than 95%. Dielectric constant(K) were affected by the theoretical dielectric polarizabilities of MZTMT ceramics. With the substitution of Zn<sup>2+</sup> for Mg<sup>2+</sup>- site, the quality factor(Qf) was improved, however, the Qf value was decreased with the increase of Zn<sup>2+</sup> content above x=0.02. These results could be attributed to the decrease of degree of covalency of sintered specimens. Effects of crystal structural characteristics on the temperature coefficient of resonant frequency(TCF) of specimens was also discussed based on the structural characteristics of ceramics.

### SW13-7 | 백색 발광 다이오드용 0차원 금속 할라이드에서 $Sb^{3+}$ 의 자기 트랩 여기자 방출 조정

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Single-component white-light-emitting materials are in high demand for lighting applications. However, achieving white light in single-doped metal halide materials remains a challenge. In this regard,  $Sb^{3+}$  doping in the zero-dimensional metal halides generally leads to self-trapped excitons (STEs) with broad tunable emission. Herein, we report the tuning of STEs emissions from green to yellow in  $Cs_3LnCl_6:Sb^{3+}$  ( $Ln = La, Y, Gd,$  and  $Lu$ ) NCs. With the increase of the  $Ln^{3+}$  size, the asymmetry in the unit cell has been enhanced. Therefore, STEs emission shifts from green to yellow region with increased  $Ln^{3+}$  size. We exploited the broad yellow STEs assisted emission from  $Sb^{3+}$  to create white light by blending with carbon dots blue emission. Interestingly, zero-dimensional  $Cs_3ScCl_6:Sb^{3+}$  (CSC: $Sb^{3+}$ ) NCs exhibit bright white-light emission. The white light emission from CSC: $Sb^{3+}$  is a result of a combination of the excessive blue and yellow emissions of carbon dots and STEs emission of  $Sb^{3+}$  ions, respectively. CSC: $Sb^{3+}$  NCs exhibit a high photoluminescence quantum yield of 48%. Furthermore, they retain 75% of their original photoluminescence efficiency at 100 °C. A single-component white-light-emitting diode was fabricated using CSC: $Sb^{3+}$  NCs exhibit a high color rendering index and luminous efficacy values of 90 and 23  $lmW^{-1}$  at a high flux current of 200 mA. Therefore, the findings may pave the way for developing the next generation of white-light-emitting devices using a single component of white-light-emitting material.

### SW13-8 | Ultrathin $Co_3O_4$ Layer on Surface-Modified Carbon Nanotubes for Enhanced Oxygen Evolution Reaction

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Alkaline water electrolysis is essential for sustainable and efficient hydrogen production. However, the sluggish kinetics in oxygen evolution reaction (OER) requires overpotential. Recently, transition metal-based electrocatalysts has been attracted great attention for improving OER performance due to the abundant active sites and efficient charge transfer. Here, we report the  $Co_3O_4$  anchored on surface-modified carbon ( $Co_3O_4@SMC$ ) for enhanced OER performance. The experimental results, combined with density functional

theory calculations, elucidate that improved OER performance is attributed to the high electrocatalytic activity of the uniformly distributed  $Co_3O_4$  on SMCs. This study offers valuable insights into the underlying mechanism of SMC-supported heterostructures for enhancing electrocatalytic performance in alkaline water electrolysis.