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Applied Physics Reviews
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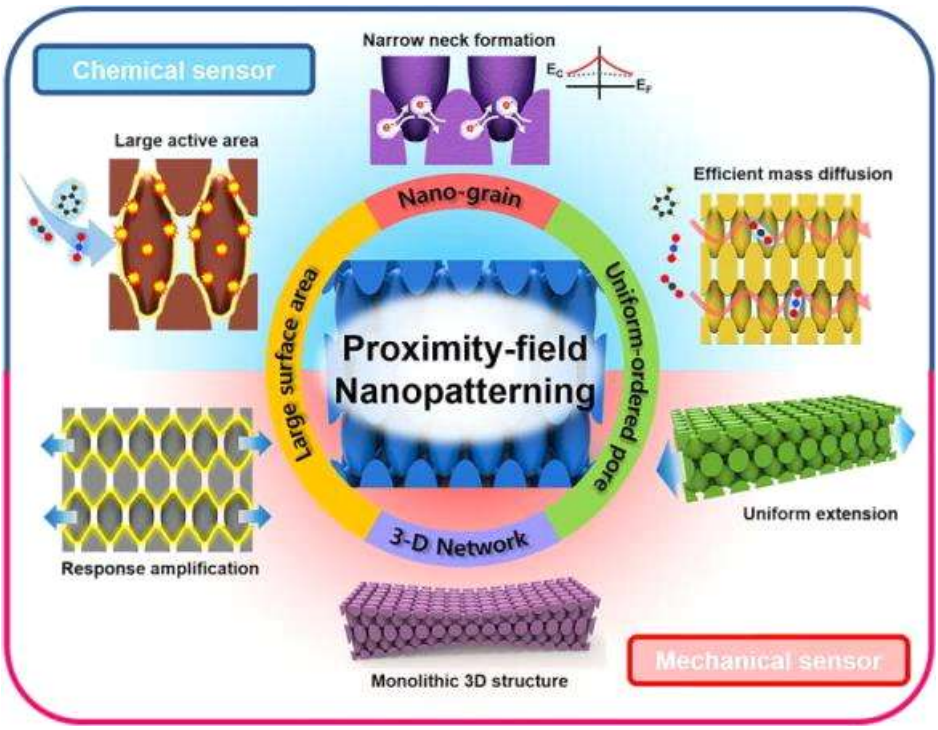
Proximity-field nanopatterning for high-performance chemical and mechanical sensor applications based on 3D nanostructures

Jinho Lee, Donghwi Cho, Haomin Chen, Young-Seok Shim*, Junyong Park*, Seokwoo Jeon*



In this era of the Internet of Things, the development of innovative sensors has rapidly accelerated with that of nanotechnology to accommodate various demands for smart applications. The practical use of three-dimensional (3D) nanostructured materials breaks several limitations of conventional sensors, including the large surface-to-volume ratio, precisely tunable pore size and porosity, and efficient signal transduction of 3D geometries. This review provides an in-depth discussion on recent advances in chemical and mechanical sensors based on 3D nanostructures, which are rationally designed and manufactured by advanced 3D nanofabrication techniques that consider structural factors (e.g., porosity, periodicity, and connectivity). In particular, we focus on a proximity-field nanopatterning technique that specializes in the production of periodic porous 3D nanostructures that satisfy the structural properties universally required to improve the performance of various sensor systems. State-of-the-art demonstrations of high-performance sensor devices such as supersensitive gas sensors and wearable strain sensors realized through designed 3D nanostructures are summarized. Finally, challenges and outlooks related to nanostructures and nanofabrication for the practical application of 3D nanostructure-based sensor systems are proposed.

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ACS Nano
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Self-Healing Graphene-Templated Platinum-Nickel Oxide Heterostructures for Overall Water Splitting

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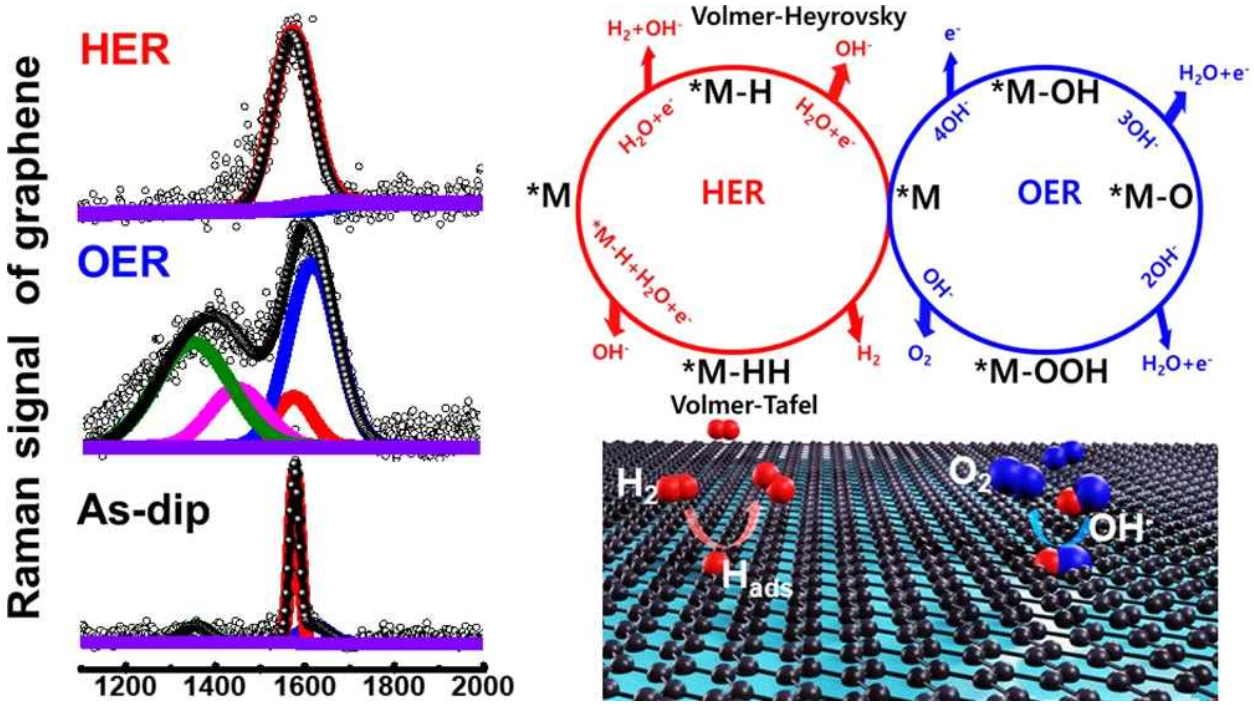


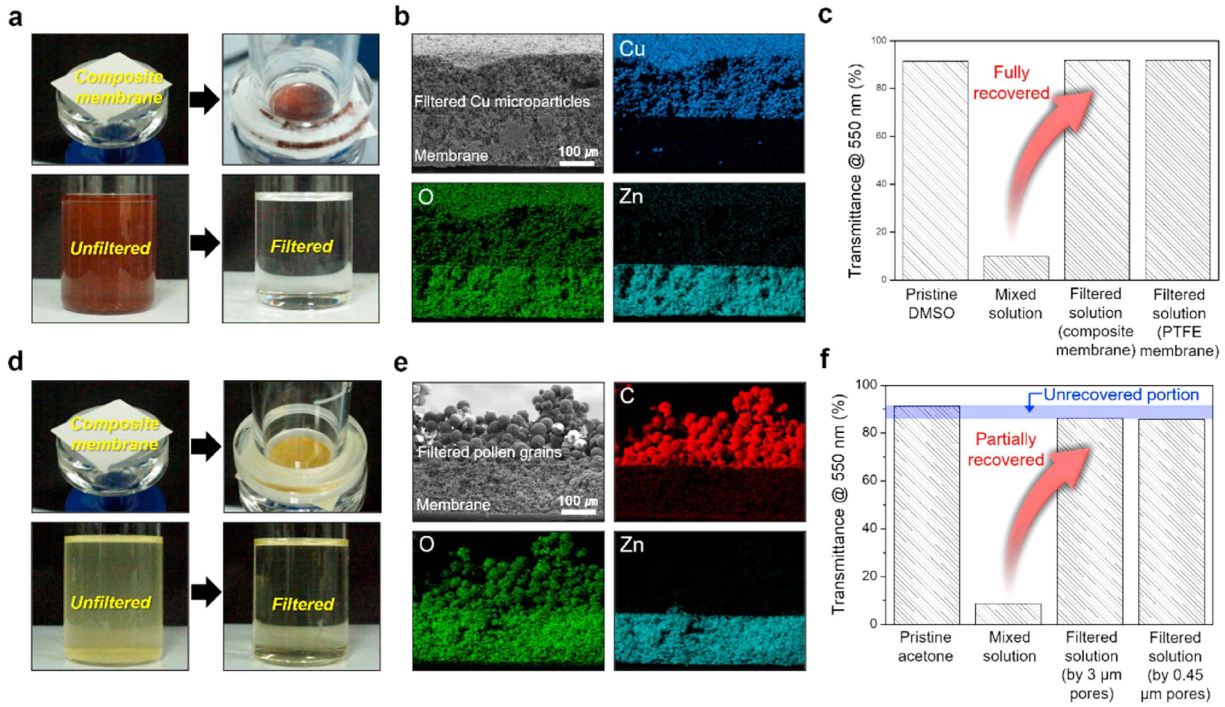
Electrocatalysts with dramatically enhanced water splitting efficiency, derived from controlled structures, phase transitions, functional activation, etc., have been developed recently. Herein, we report an in situ observation of graphene-based self-healing, in which this functional activation is induced by a redox reaction. Specifically, graphene on stainless steel (SUS) switches between graphene (C-C) and graphene oxide (C-O) coordination via an electrical redox reaction to activate water splitting. A heterostructure comprising Pt-NiO thin films on single-layer graphene directly grown on a SUS substrate (Pt-NiO/Gr-SUS) was also synthesized by electrodeposition. Pt-NiO/Gr-SUS exhibited water splitting activity with low Pt loading (<1 wt %). The findings provide valuable insight for designing robust electrodes based on reversible redox-induced self-healable graphene to develop more efficient catalysts.

에너지변환

Journal of Membrane Science
Volume 651, March 2022, p120455 (Impact Factor : 8.742)

Composite membranes with ultrathin and conformal passivation for universal microfiltration compatible with organic solvents

Junyong Ahn, Taehyun Ryu, Junyong Park*



The development of porous membranes with excellent solvent resistances is an important technical task in relation to environmental and energy issues, including chemical waste treatment in the semiconductor industry. However, common polymer membranes, except for Teflon-based membranes, do not guarantee universal resistance to various organic solvents. In this study, a universal strategy is proposed to improve the solvent resistances of polymeric porous membranes through conformal passivation of ultrathin metal oxide layers via atomic layer deposition. Conformal ZnO shells with a thickness below ~62 nm can significantly improve the inherently low resistances of nitrocellulose, polyethersulfone, and polycarbonate membranes to organic solvents without significantly degrading the flux. Although the polymer core is gradually dissolved by the organic solvent penetrating through the native cracks of the ZnO shell as the time of exposure to the organic solvent increases, the rigid porous network composed of hollow ZnO can well maintain its monolithic form for more than 1 week. Thus, it is possible to effectively filter pollen grains and heavy metal microparticles dispersed in harsh organic solvents without expensive Teflon-based membranes. This study opens new opportunities for selection of organic solvent-compatible membranes for microfiltration.

에너지변환

Advanced Theory and Simulations
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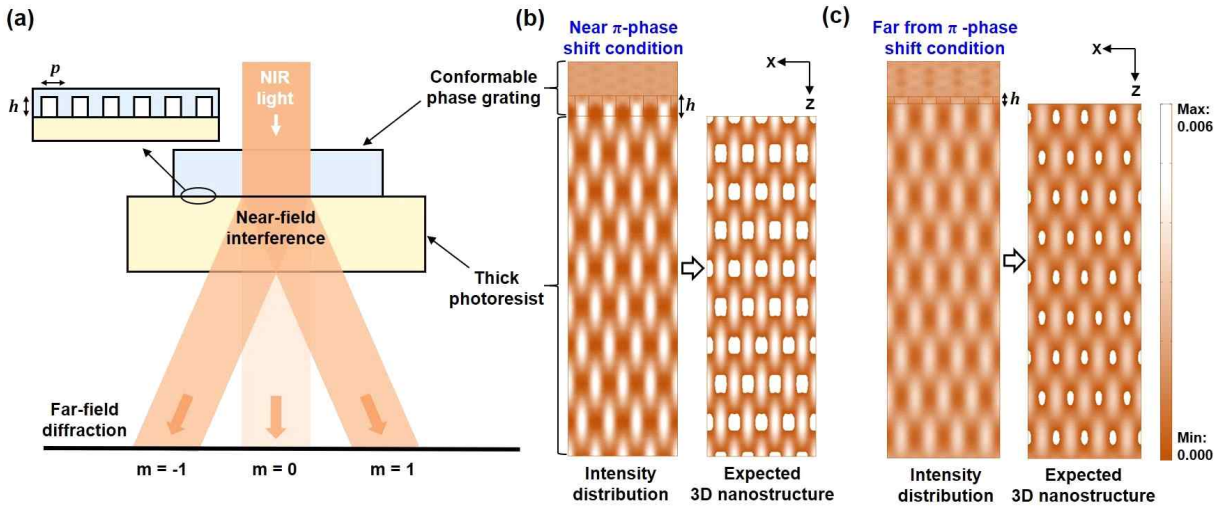
Optimal design of surface relief grating for high-resolution two-photon interference lithography

Jinseong Ahn, Junyong Park*



Two-photon interference lithography with an elastomeric phase grating that allows spontaneous conformal contact to the photoresist can be used to fabricate practical-scale, 3D photonic crystals through a single exposure. In principle, the unit cell symmetry and fill factor of the 3D periodic nanostructures produced using this technique are strongly depend on the structural parameters of the phase grating. However, theoretical approaches to derive the optimal parameters of the phase grating for realizing high-definition 3D nanostructures are still lacking. Here, the change in the Talbot interference pattern is systematically predicted with the relief height of the phase grating under the conditions in which two-photon interference lithography is performed through optical simulations. The collective set of results reveals the design error of the relief height of the phase grating, as inferred by the scalar approximation thus far, and presents the optimal condition that satisfies the π-phase shift inferred by the full-vectorial numerical solution.

태양에너지

Nanomaterials
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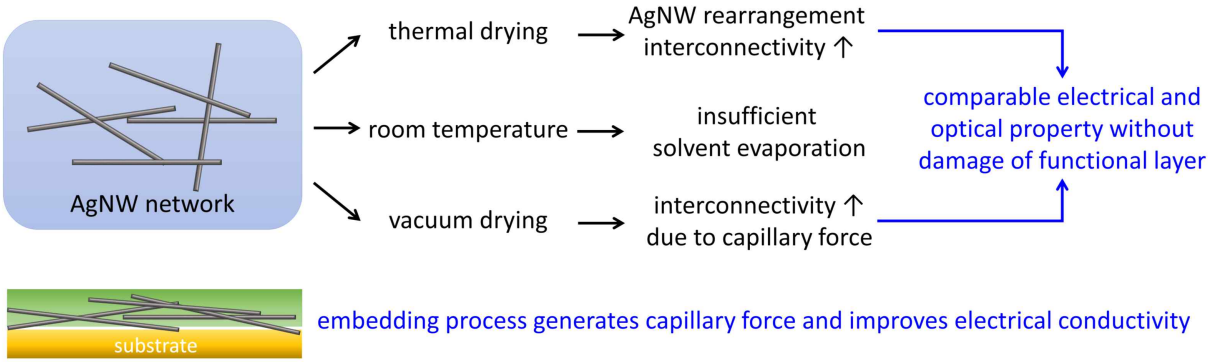
Characterization of silver nanowire-based transparent electrodes obtained using different drying methods

Seo Bum Chu, Dongwook Ko, Jinwook Jung, Sungjin Jo, Dong Choon Hyun, Hyeon-Ju Oh, Prof. Jongbok Kim



Metal-based transparent top electrodes allow electronic devices to achieve transparency, thereby expanding their application range. Silver nanowire (AgNW)-based transparent electrodes can function as transparent top electrodes, owing to their excellent conductivity and transmittance. However, they require a high-temperature drying process, which damages the bottom functional layers. Here, we fabricated two types of AgNW-based electrodes using the following three drying methods: thermal, room-temperature, and vacuum. Thereafter, we investigated the variation in their morphological, electrical, and optical characteristics as a function of the drying method and duration. When the AgNW-exposed electrode was dried at room temperature, it exhibited a high surface roughness and low conductivity, owing to the slow solvent evaporation. However, under vacuum, it exhibited a similar electrical conductivity to that achieved by thermal drying because of the decreased solvent boiling point and fast solvent evaporation. Conversely, the AgNW-embedded electrodes exhibited similar roughness values and electrical conductivities regardless of the drying method applied. This was because the polymer shrinkage during the AgNW embedding process generated capillary force and improved the interconnectivity between the nanowires. The AgNW-based electrodes exhibited similar optical properties regardless of the drying method and electrode type. This study reveals that vacuum drying can afford transparent top electrodes without damaging functional layers.

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Physical Chemistry Chemical Physics
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Atomistic level aqueous dissolution dynamics of NASICON-Type $Li_{1+x}Al_xTi_{2-x}(PO_4)_3$

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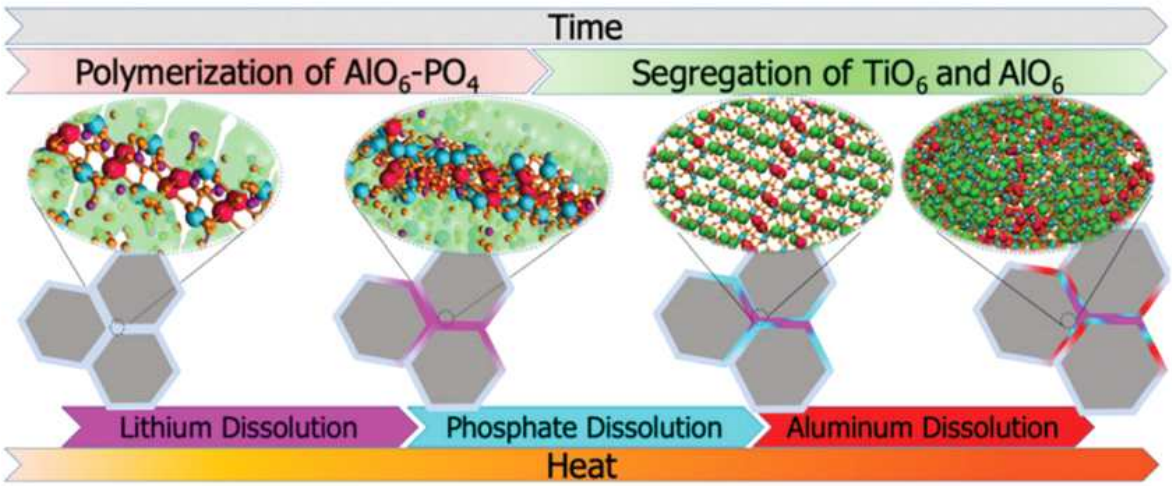

In this work, we find that the dissolution of NASICON-typematerials can be very complex; however, once better understood, it may be possible to limit incongruent dissolution via smartly designed solutions, for example, by adding electrolyte species to tune dissolution of ions of interest. Our results show that the dissolution of LATP is a sequentially dynamic process. The process starts with the removal of Li ions, which changes the charge distribution inside the crystal. This change triggers a bonding transition inside crystal, which results in dissolution Al as a polymerized AlO_6-PO_4 chains. With the dissolution of PO_3 groups, TiO_6 groups switch to a more stable phase. Our results may be relevant to other NASICON-type materials and may also be of interest to the design of future experiments in solution-based methods.