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KIT Energy News

에너지융합기술 혁신인재 양성사업단

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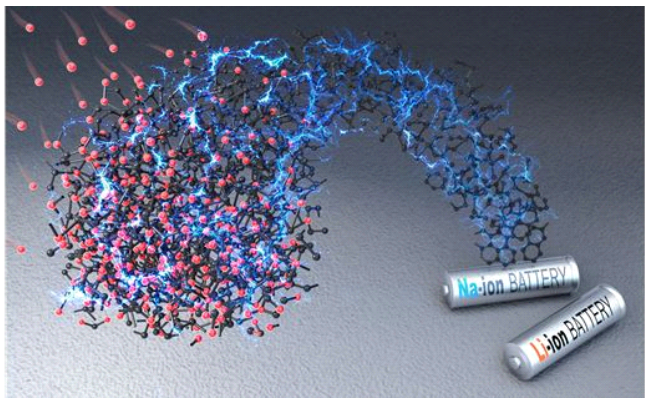
< 목 차 >

KIT Energy 소식

박철민 교수 연구팀, '차세대 고성능 도전재용 탄소계 소재 제조 기술 개발'

- 기존 전극 소재의 전도성뿐만 아니라 초기효율 및 가역용량 동시 향상 가능
- 다양한 이차전지 시스템에 활용성 높아





우리 대학 신소재공학부 전지신소재연구실(Advanced Battery Materials Lab.) 박철민 교수 연구팀이 '차세대 고성능 도전재용 탄소계 소재의 제조 기술 개발'에 성공했다.

박철민 교수 연구팀은 리튬이차전지의 도전재(Conducting Agent)로 널리 사용 중인 탄소계 소재(카본블랙)에 알칼리 금속(리튬, 나트륨, 칼륨)으로 간단한 전처리를 하여 리튬이온 이차전지 및 차세대 이차전지(나트륨, 칼륨)의 고성능 도전재로 적용하였다.

이렇게 제조한 탄소계 소재를 도전재로 사용할 경우, 기존 전극 소재의 전도성 향상에만 사용되었던 도전재용 탄소계 소재에 비해 전극 소재의 전도성 향상 이외에 추가적으로 초기효율 및 가역용량 또한 크게 향상시킬 수 있는 것으로 연구 결과 확인됐다. 따라서 리튬이온 이차전지뿐만 아니라 차세대 나트륨 및 칼륨 이온 이차전지를 위한 차세대 고성능 도전재용 탄소계 소재의 활용에도 높이 기여할 것으로 기대하고 있다.

다양한 이차전지 시스템과 고용량 전극 소재 개발 등 차세대 산업 동력을 위한 연구를 지속적으로 이어오고 있는 박철민 교수는 "이번 성과는 전극 소재에 치중되어 있는 이차전지 관련 연구에 고성능 도전재 소재 분야로의 새로운 패러다임을 제시한 것"이라고 밝혔다.

이번 연구는 신소재공학과 박사과정의 남기훈 연구원이 제1저자로 참여했으며 전기준 인하대 환경공학과 교수, 채근화 한국과학기술연구원 박사, 최정희 한국전기연구원 박사, Ganesan Vinoth 우리 대학 신소재공학과 박사와의 공동 연구로 진행됐다. 관련 연구는 학술지 Chemical Engineering Journal(IF: 13.273) 및 Carbon(IF: 9.594)의 온라인판에 최근 게재됐으며, 관련 특허 3건도 등록 및 출원됐다. 4단계 BK21사업, 중견연구자지원사업, 대학중점연구소지원사업 및 우리 대학 Grand-ICT연구센터 지원으로 수행됐다.

금오공과대학교 KIT People(2021.07.19) https://www.kumoh.ac.kr/ko/sub01_05_02.do?mode=view&articleNo=316777

◈ 관련 기사 ◈

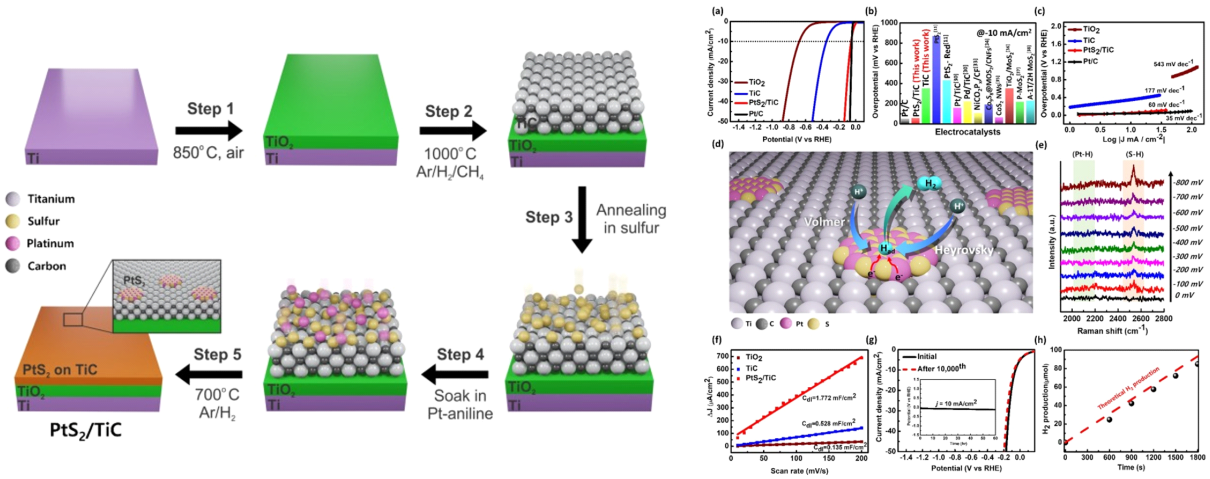
NewDaily	금오공대 박철민 교수 연구팀, '차세대 고성능 도전재용 탄소계 소재 제조 기술 개발'	http://tk.newdaily.co.kr/site/data/html/2021/07/19/2021071900157.html
news1	금오공대 박철민 교수 연구팀, 차세대 도전재용 탄소계 소재 제조 기술 개발	https://www.news1.kr/articles/4376358
NEWSIS	금오공대 박철민 교수 연구팀, 탄소계 소재 기술개발 성공	https://newsis.com/view/?id=NISX20210719_0001518226
UNN	금오공대 연구팀, '차세대 고성능 도전재용 탄소계 소재 제조 기술' 개발	https://news.unn.net/news/articleView.html?idxno=512691
경북도민일보	'도전재 소재 집중' 이차전지 연구 새 지평	http://www.hidomin.com/news/articleView.html?idxno=459112
경북매일신문	금오공대, 고성능 도전재용 탄소계 소재 제조기술 개발	http://www.kbmaeil.com/news/articleView.html?idxno=904630
국제뉴스	금오공대 박철민 연구팀, '고성능 도전재용 탄소계 소재 제조 기술' 개발	http://www.gukjenews.com/news/articleView.html?idxno=2271068
데일리한국	금오공대 박철민 교수 연구팀, 탄소계 소재 제조 기술 개발에 성공	http://daily.hankooki.com/lpage/society/202107/dh20210719185720148520.htm
매일신문	금오공대 박철민 교수 연구팀, '차세대 고성능 도전재용 탄소계 소재 제조 기술개발'	https://news.imaeil.com/Society/2021071915232990275
머니투데이	금오공대, 차세대 고성능 도전재용 탄소계 소재 제조 기술 개발	https://news.mt.co.kr/mtview.php?no=2021071915197444761
베리타스알파	금오공대 박철민 교수 연구팀, '차세대 고성능 도전재용 탄소계 소재 제조 기술 개발'	http://www.veritas-a.com/news/articleView.html?idxno=377650
서울경제	차세대 고성능 도전재용 탄소계 소재 제조기술개발	https://www.sedaily.com/NewsView/22OZHYV5YA/GK0208

수소에너지

Applied Catalysis B: Environmental
Volume 293, September 2021, p120227 (Impact Factor : 19.503)

Atomic interactions of two-dimensional PtS_2 quantum dots/TiC heterostructures for hydrogen evolution reaction

Sangmin Jeong, Hien Duy Mai, Tri Khoa Nguyen, Jong-Sang Youn, Ki-Hun Nam, Ki-Joon Jeon*, Cheol-Min Park*



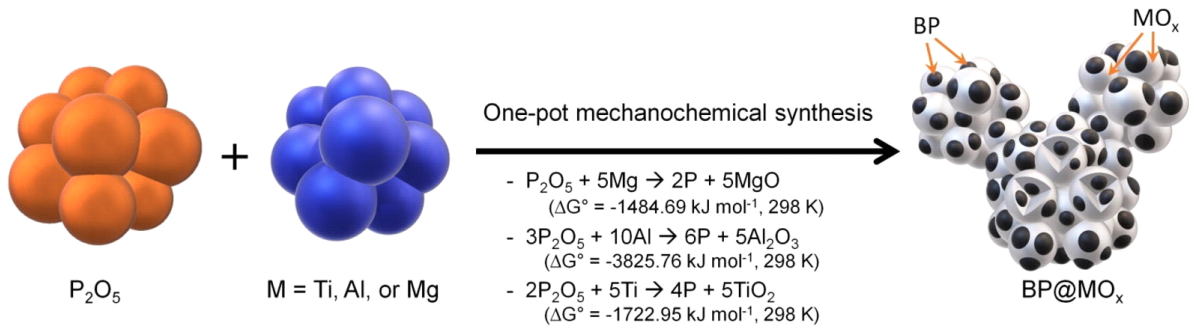
Two-dimensional quantum dots (2D QDs) comprising PtS_2 with low Pt loading (0.002 wt.%) distributed on a distinctive CVD-grown titanium carbide substrate (PtS_2/TiC) was successfully synthesized and employed for a hydrogen evolution reaction (HER). Notably, despite the low loading of the former component, PtS_2/TiC showed excellent HER activity with a superior overpotential (55 mV at 10 mA/cm^{-2}) to that of commercial Pt/C (50 mV at 10 mA/cm^{-2}). The Faraday efficiency of PtS_2/TiC was found to be 92.5 %, revealing the superior properties of hydrogen production. The In-situ Raman spectra reveal the important role of S atoms in PtS_2 as the active sites for HER, as evidenced by Ssingle bondH bonding formation at 2532 cm^{-1} during the HER process. This study provides a fundamental understanding essential for the design of more efficient catalysts in the field of electrochemical applications.

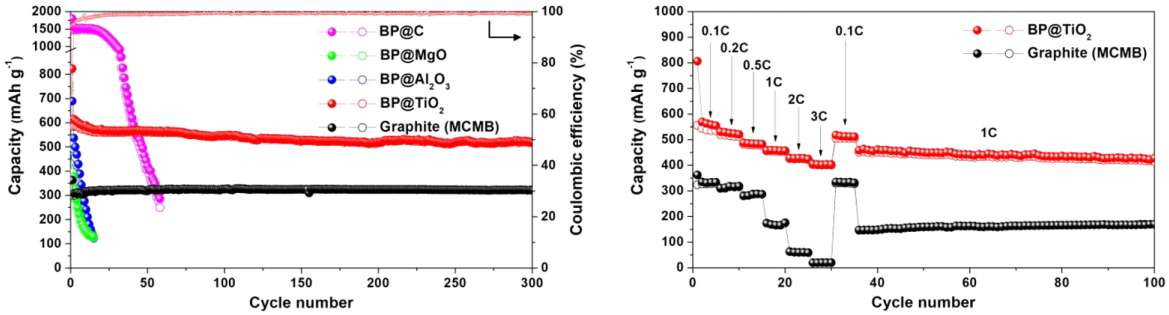
에너지저장

Chemical Engineering Journal
Volume 424, November 2021, p130366 (Impact Factor : 13.273)

Black P@MO_x (M = Mg, Al, or Ti) composites as superior Li-ion battery anodes

Tae-Hyun Kim, Ki-Joon Jeon*, Cheol-Min Park*





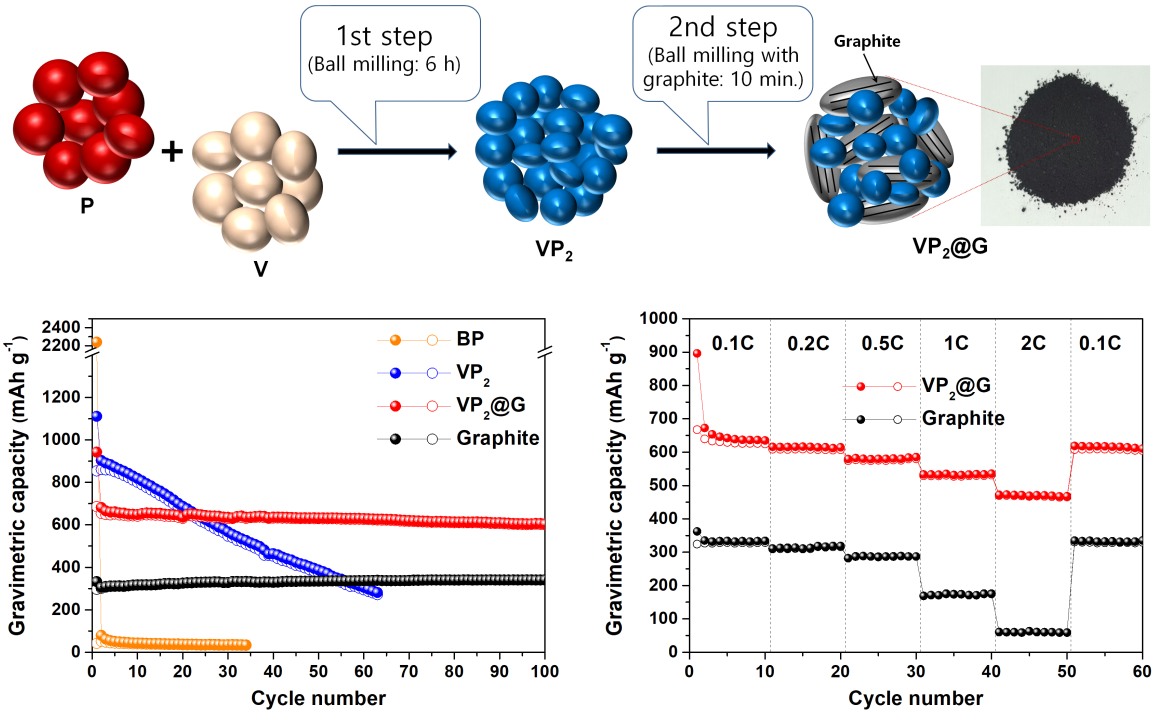
A simple, inexpensive, and scalable method for transforming phosphorous pentoxide (P_2O_5) into black phosphorus (BP)-based composites was developed. The BP-based composites of BP@MgO, BP@Al_2O_3, and BP@TiO_2 synthesized by a one-pot mechanochemical reduction of P_2O_5 using Mg, Al, or Ti were composed of nanocrystalline BP within the metal oxide matrices of MgO, Al_2O_3, or TiO_2, respectively. Subsequently, the potential of these composites as anode materials in rechargeable Li-ion batteries (LIBs) was investigated. BP@TiO_2 showed the highest electrochemical performance among the BP-based composites. Specifically, the BP@TiO_2 exhibited a high reversible capacity over 510 mAh g^{-1} after 300 cycles and a fast rate capability of ~ 400 mAh g^{-1} at the 3C rate. The superior electrochemical performance of BP@TiO_2 was attributed to the well-dispersed nanocrystalline BP and the Li-reactive TiO_2 matrix. Additionally, the formation of Li_xTiO_2 in the Li-reactive TiO_2 matrix during Li cycling increased the electrochemical Li-ion conductivity and diffusivity, contributing to the enhanced electrochemical performance. Therefore, the BP@TiO_2 synthesized by the one-pot mechanochemical reduction has high potential as a superior LIB anode.

에너지저장

Journal of Alloys and Compounds
Volume 875, September 2021, p160061 (Impact Factor : 5.316)

Monoclinic vanadium diphosphide as a high-performance lithium-ion battery anode

Heung-Su Kim, Ki-Hun Nam, Cheol-Min Park*



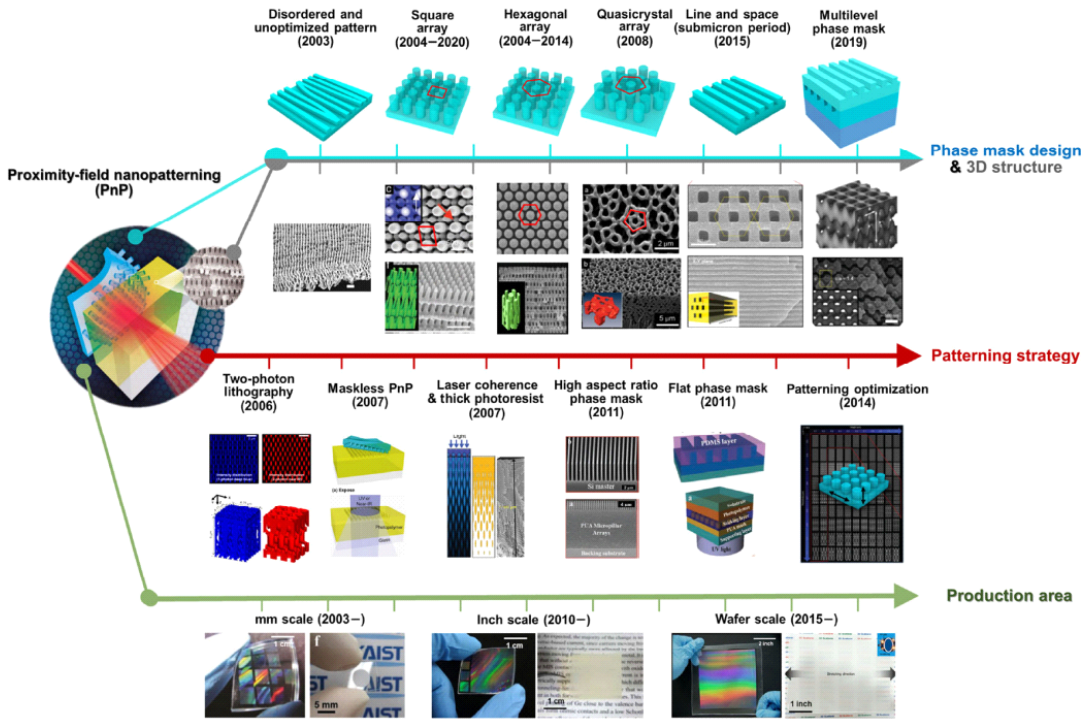
Vanadium diphosphide (VP_2) and its graphite-modified composite (VP_2@G) were fabricated using a fast and simple solid-state manner, and evaluated as Li-ion battery (LIB) anodes. The electrochemical Li-mechanism of VP_2 was investigated using various ex situ tools. During Li-insertion, VP_2 underwent a topotactic-reaction by the formation of Li_xVP_2 ($x \leq 1.5$), and then was converted to Li_3P and V phases with a partially unconverted Li_xVP_2 phase at the Li-inserted state of 0 V via a partial conversion reaction. Conversely, during Li-extraction, Li3P, V, and unconverted Li_xVP_2 phases recombined fully into VP_2. First, when VP_2 was used the topotactic-reaction between Li_xVP_2 and VP_2 (potential region: 0.3-2.0 V), stable cycling performance with a high volumetric-capacity (595 mAh cm^{-3} after 100 cycles) and fast rate performance (~555 mAh cm^{-3} at 2 C and ~530 mAh cm^{-3} at 3 C) were attained. Additionally, the graphite-modified composite VP_2@G (potential region: 0-2.0 V) also exhibited stable cycling performance with a high gravimetric-capacity (602 mAh g^{-1} after 100 cycles) and fast rate performance (~530 mAh g^{-1} at 1 C and ~470 mAh g^{-1} at 2 C), which was attributed to the well-dispersed nanocrystalline (~10-20 nm) VP_2 in the Li-buffering graphite matrix. Therefore, the VP_2 and VP_2@G have high potential as a superior LIB anode.

에너지변환

Nano Research
Volume 14, No. 9, September 2021. p2965-2980 (Impact Factor: 8.897)

Fundamental principles and development of proximity-field nanopatterning toward advanced 3D nanofabrication

Sang-Hyeon Nam, Gayea Hyun, Donghwi Cho, Seonggon Han, Gwangmin Bae, Haomin Chen, Kisun Kim, Youngjin Ham, **Junyong Park***, Seokwoo Jeon*



Three-dimensional (3D) nanoarchitectures have offered unprecedented material performances in diverse applications like energy storages, catalysts, electronic, mechanical, and photonic devices. These outstanding performances are attributed to unusual material properties at the nanoscale, enormous surface areas, a geometrical uniqueness, and comparable feature sizes with optical wavelengths. For the practical use of the unusual nanoscale properties, there have been developments for macroscale fabrications of the 3D nanoarchitectures with process areas over centimeter scales. Among the many fabrication methods for 3D structures at the nanoscale, proximity-field nanopatterning (PnP) is one of the promising techniques that generates 3D optical holographic images and transforms them into material structures through a lithographic process. Using conformal and transparent phase masks as a key factor, the PnP process has advantages in terms of stability, uniformity, and reproducibility for 3D nanostructures with periods from 300 nm to several micrometers. Other merits of realizing precise 3D features with sub-100 nm and rapid processes are attributed to the interference of coherent light diffracted by phase masks. In this review, to report the overall progress of PnP from 2003, we present a comprehensive understanding of PnP, including its brief history, the fundamental principles, symmetry control of 3D nanoarchitectures, material issues for the phase masks, and the process area expansion to the wafer-scale for the target applications. Finally, technical challenges and prospects are discussed for further development and practical applications of the PnP technique.

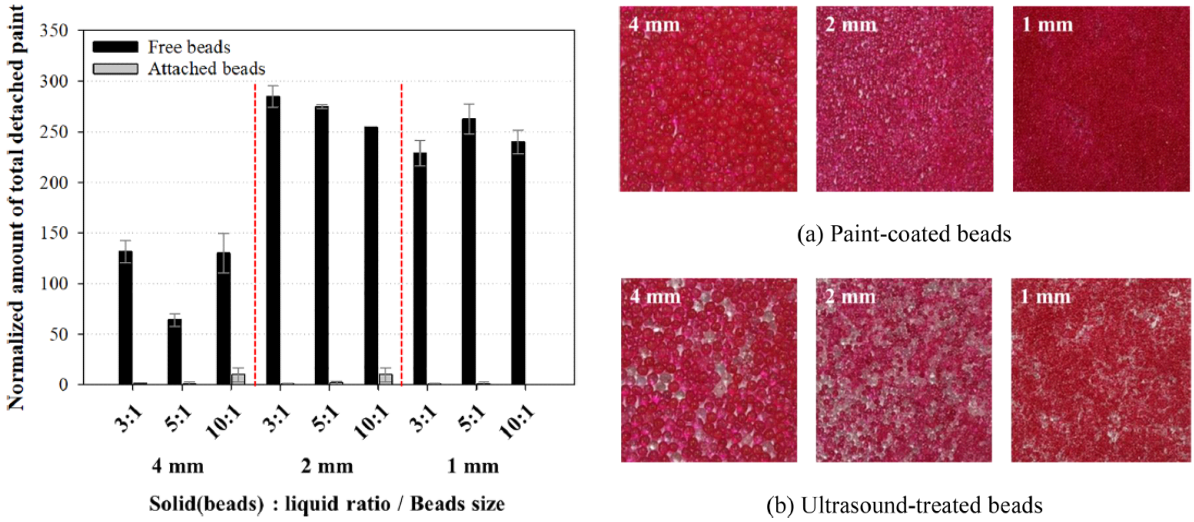
환경에너지

Ultrasonics Sonochemistry

Volume 74, June 2021, p.105574 (Impact Factor : 7.491)

Ultrasound-assisted soil washing processes for the remediation of heavy metals contaminated soils: The mechanism of the ultrasonic desorption

Jongbok Choi, Dukyoung Lee, Younggyu Son



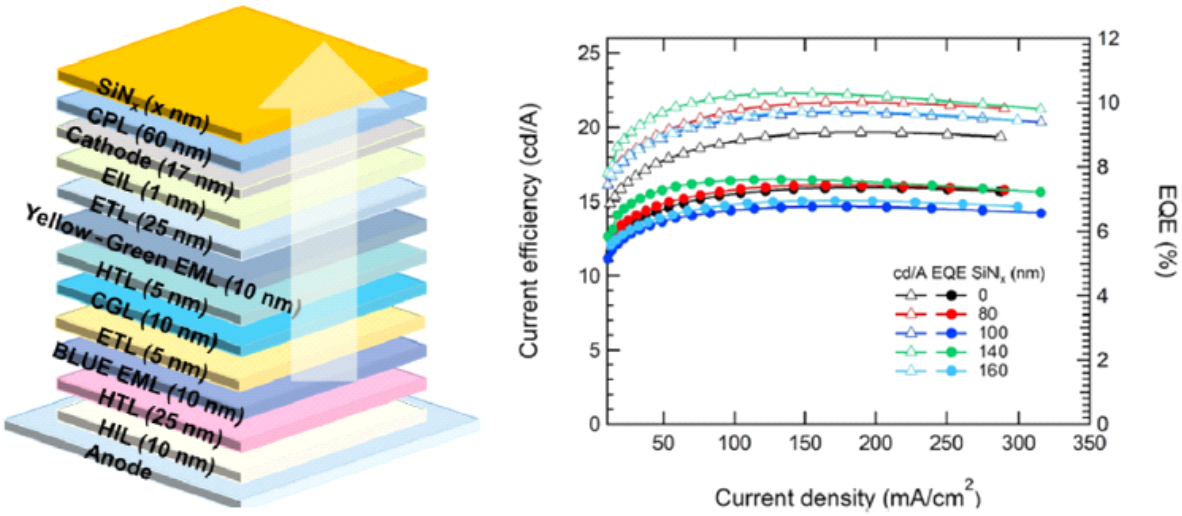
Ultrasound-assisted soil washing processes were investigated for the removal of heavy metals (Cu, Pb, and Zn) in real contaminated soils using HCl and EDTA. The ultrasound-assisted soil washing (US/Mixing) process was compared with the conventional soil washing (Mixing) process based on the mechanical mixing. High removal efficiency (44.8% for HCl and 43.2% for EDTA) for the metals was obtained for the most extreme conditions (HCl 1.0 M or EDTA 0.1 M and L:S = 10:1) in the Mixing process. With the aide of ultrasound, higher removal efficiency (57.9% for HCl and 50.0% for EDTA) was obtained in the same extreme conditions and similar or higher removal efficiency (e.g., 54.7% for HCl 0.5 M and L:S = 10:1 and 50.5% for EDTA 0.05 M and L:S = 5:1) was achieved even in less extreme conditions (lower HCl or EDTA concentration and L:S ratio). Therefore, it was revealed that the US/Mixing was advantageous over the conventional Mixing processes in terms of metal removal efficiency, consumption of chemicals, amount of generated washing leachate, and volume/size of washing reactor. In addition, the heavy metals removal was enhanced for the smaller soil particles in the US/ Mixing process. It was due to more violent movement of smaller particles in slurry phase and more violent sonophysical effects. In order to understand the mechanism of ultrasonic desorption, the desorption test was conducted using the paint-coated beads with three sizes (1, 2, and 4 mm) for the free and attached conditions. It was found that no significant desorption/removal of paint from the beads was observed without the movement of beads in the water including floatation, collision, and scrubbing. Thus, it was suggested that the simultaneous application of the ultrasound and mechanical mixing could enhance the physical movement of the particles significantly and the very high removal/desorption could be attained.

태양에너지

Organic Electronics
Volume 97, June 2021, p106261 (Impact Factor : 3.721)

Hydrogen-assisted low-temperature plasma-enhanced chemical vapor deposition of thin film encapsulation layers for top-emission organic light-emitting diodes

Junmo Kim, Jeong Ha Hwang, Yong Woo Kwon, Hyeong Woo Bae, Myungchan An, Wonho Lee*, Donggu Lee*



In this work, we developed a single high-performance SiNx encapsulation layer that can be directly integrated into organic devices by low-temperature plasma-enhanced chemical vapor deposition (PECVD). We investigated a hydrogen-assisted low-temperature PECVD process at a temperature of 80 ℃. The thin film density improved with an increased hydrogen gas ratio, and the moisture permeability was less than 5×10^{-5} g/m^2·day. To verify the stability of the PECVD process, we applied the SiNx encapsulation layer directly to top-emitting organic light-emitting diodes. The results showed minor changes in the current-density-voltage characteristics after the PECVD process, as well as high reliability after a water dipping test.