◆ Physicochemical and Structural properties of Silica Films Prepared from Perhydropolysilazane Using Vacuum Ultraviolet Irradiation

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Silica films were prepared by irradiating perhydropolysilazane (PHPS) with vacuum ultraviolet (VUV) light under a controlled atmosphere. The quality of the resulting films and the mechanisms behind their photochemical conversion were investigated. The results revealed that silica forms on the top surface, while either silica or silicon oxynitride forms within the film, depending on the oxygen concentration. PHPS was converted to silica from both the surface and substrate sides. Silica formation occurred even far from the irradiation source. These findings demonstrate that the formation involves two processes: bond cleavage induced by VUV photons and oxidation due to oxygen diffusion from the surface. Spectroscopic and structural measurements indicated that the properties of the prepared film were comparable to those of a film prepared through heat treatment at 500 °C. Additionally, the VUV-assisted formation process suppressed film shrinkage during the conversion of PHPS to silica.

◆Material and Antibacterial Properties of Spinel-Structure Ca-Doped $ZnCo_2O_4$ Thin Films

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コバルト(Co)をカルシウム(Ca)で置換した Ca ドーピング Zn(Co,Ca)2O4 酸化物薄膜をゾルゲル法により水晶基板上に成膜し、抗菌性について報告している。Ca をドーピングすると酸化物薄膜の粒径が縮小し、表面微細構造が平坦化され、薄膜の青色および紫外線吸収能力が低下し、Zn(Co,Ca)2O4 の吸収特性が減少することが分かった。

今回、ドーピングを最大 20%まで試みたが、導電性とキャリア濃度が増加する 7%が最適値であった。その結果、紫外線照射下および光源のない環境下において、この膜は大腸菌に対して光源の有無に関わらず高い耐性を示した。

◆ Surface Patterning of Wide-Gap Semiconducting β-Ga_2O_3 Thin Films by Area Selective Crystallization via Room-Temperature Excimer Laser Annealing and Low Toxic Wet-Etching Processes

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従来、金属酸化物パワー半導体材料であるβ相酸化ガリウム（β-Ga_2O_3）の表面微細加工には高反応性の酸（フッ酸・硫酸等）やプラズマガスが必要とされてきた。本研究では、非晶質 Ga_2O_3 薄膜への位置選択的な深紫外レーザー照射による結晶化と酸溶液エッチングプロセスからなる、室温・低毒性のβ相酸化ガリウム薄膜の表面パターニン

グ法を開発した。本技術により、毒性試薬を用いた作業や浄化設備を必要としないウルトラワイドギャップ（禁制帯幅 ＞4 eV）半導体に特化した環境低負荷な新規微細加工法が実現可能となった。

◆Room Temperature Nanoimprint Aided by Electron Beam Irradiation for Polysilsesquioxane,

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近年，無機ナノ周期構造の応用研究が活発になっている．本研究では、無機ナノ周期構造の形成技術として、高沸点溶媒に溶解したポリシルセスキオキサン(PSQ)を用いた室温ナノインプリントを提案した．PSQ は加水分解に安定な有機-無機ハイブリッド材料として知られており，高電子線照射により架橋した PSQ ナノパターンは 200℃の加熱下でも形状を維持していた．また、フーリエ変換赤外分光光度計(FT-IR)による分析の結果，シロキサン結合(Si-O-Si 結合)が PSQ の骨格を構成していることが確認できた．さらに、電子線照射により架橋した PSQ の Si-O-Si 結合のピーク波数は 1115cm^{-1} から 1135cm^{-1} へと高波数側にシフトしていた。この結果は，電子線照射した PSQ の物性が石英に近づいていることを示唆し、ドライエッチングに不可欠なハードマスクへ応用できる可能性を示している．

◆Chromia Photodeposition on a Gold-Inserted Iron Disilicide and Rutile Titanium Dioxide Heterojunction Photocatalyst and Its Water-splitting Reaction

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掲載紙：ACS Applied Energy Materials, Vol.8, No.9, pp.6016-6024(2025)

A solid-state Z-scheme system is constructed using a sputtering method in which rutile titania (TiO_2) and beta-iron disilicide (β-$FeSi_2$), which act as oxygen- and hydrogen-evolution photocatalysts, respectively, are combined with gold (Au), which acts as a solid electron mediator (β-$FeSi_2$/Au/TiO_2). Platinum (Pt) is selectively deposited onto β-$FeSi_2$ using the photoexcitation of only β-$FeSi_2$ to prepare Pt-loaded β-$FeSi_2$/Au/TiO_2, followed by selective loading of chromium oxide (CrO_x) onto Pt. In this study, we attempted that CrO_x was photodeposited onto both TiO_2 and Pt on β-$FeSi_2$ by the photoexcitation of both TiO_2 and β-$FeSi_2$ to prepare Pt/β-$FeSi_2$/Au/TiO_2/CrO_x. We confirmed that CrO_x was precipitated on the surface of not only the β-$FeSi_2$ grain but also TiO_2 around the β-$FeSi_2$ grain in Pt/β-$FeSi_2$/Au/TiO_2/CrO_x. The Pt/β-$FeSi_2$/Au/TiO_2/CrO_x with 2 wt% CrO_x photocatalyst greatly enhanced the overall water-splitting activity (more than 10 times) compared with CrO_x/Pt/β-$FeSi_2$/Au/TiO_2 with 0.4 wt% CrO_x.

◆Synergistic Effects of Photocatalysis, Ozone Treatment, and Metal Catalysts on the Decomposition of Acetaldehyde

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This study explores the synergistic interactions between photocatalysis, ozone treatment, and metal catalysts in the decomposition of acetaldehyde, a representative volatile organic compound (VOC). The study addresses the growing need for efficient air purification

technologies by integrating advanced oxidation processes. Metal catalysts, particularly manganese oxide-based materials, were combined with photocatalysis and ozonation to investigate their impact on acetaldehyde removal efficiency. Experimental results revealed that the treatment integrating these methods significantly outperformed conventional single-process treatments. Metal catalysts facilitated the initial oxidation of acetaldehyde, while photocatalysis accelerated subsequent stages, including the mineralisation of intermediates. Ozone contributed additional reactive oxidative species, further enhancing decomposition rates. These findings provide valuable insights into the design of efficient VOC removal systems, demonstrating that integrating metal catalysts with photocatalytic and ozonation processes offers a promising strategy for improving air purification technologies. This approach has potential applications in environmental remediation and indoor air quality management.

◆Commercialization Aspects for TiO_2-Based Indoor Air Purification

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掲載紙：Trends in Chemistry, Vol. 7, No.3 pp.134(2025)

TiO_2-based photocatalytic oxidation (PCO) has great potential and prospects for the elimination of indoor air pollutants under ambient conditions without complex reactions. Various novel photocatalytic structures have been extensively developed on the laboratory scale. However, future commercial applications of this technology are limited due to complicated indoor air pollutants, photocatalytic reactors, and environmental complexity. This review mainly summarizes the practical issues of TiO_2-based indoor air purification, with special emphasis on photon utilization, deactivation-resistance and regeneration, photocatalyst immobilization, upgraded reactor configuration, and PCO hybridized with other techniques. Finally, future perspectives of TiO_2-based air purification are proposed to demonstrate the innovative commercialization direction. This review endeavors to provide more reference value for the commercialization of TiO_2-based multifunctional reactors for indoor air purification.

◆ Investigation of the Temperature Coefficients of Perovskite Solar Cells for Application in High-Temperature Environments

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掲載紙：Chem Asian Journal, Vol.19, No.19, (2024)

Perovskite solar cells are actively investigated for their potential as highly efficient and cost-effective photovoltaic devices. However, a significant challenge in their practical application is enhancing their durability. Particularly, these cells are expected to be subjected to heating by sunlight in real-world operating environments. Therefore, high-temperature durability and device operation under such conditions are critical. Our study aims to improve the durability of perovskite solar cells for practical applications by examining their

temperature coefficients at elevated temperatures using MA-free compositions. We assessed these coefficients and investigated their correlation with the ideality factor, revealing that carrier recombination markedly affects the temperature behavior of these cells. Our methodology involves simple J-V measurements to evaluate device degradation at high temperatures, paving the way for further research to enhance device performance in such environments.

◆Modified Resazurin Ink Testing and the Fluorescence Probe Method for Simple and Rapid Photocatalytic Performance Evaluation

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Evaluating the air purification performance of photocatalytic materials typically requires complex gas decomposition tests involving expensive analytical equipment and lengthy testing periods. In this study, photocatalytic performance evaluation methods involving resazurin (Rz) ink and fluorescence probe techniques were investigated as alternatives to conventional gas decomposition tests. TiO_2 films with varying performance levels were fabricated by controlling TiO_2 slurry concentration and the amount of photocatalyst deposited through spin coating. Photocatalytic performances of the synthesised films were then evaluated using the acetaldehyde decomposition method, Rz ink test, and fluorescence probe method for measuring OH radical generation. The acetaldehyde decomposition rate constants showed high correlation with both the Rz colour change rate in modified-pH ink (R^2 = 0.91) and the OH radical concentration (R^2 = 0.98). Conventional Rz ink testing for high-performance materials showed rapid colour changes, indicating its limited applicability. Our modified-pH Rz ink enabled facile analysis by ensuring controlled reactivity. Both the modified Rz ink method, which enables quantitative evaluation within five minutes even for high-performance materials, and the fluorescence probe method are suitable as reliable screening tools for photocatalytic air purification materials. These simplified evaluation methods will aid in developing more efficient photocatalysts and advancing environmental purification technologies.