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Peculiarities of Cr-doped ZnO

The recently discovered ZnO-Cr_2O_3-based varistor ceramic, with Cr_2O_3 as the varistor former and oxides of Ca and Co as performance enhancers, represents a significant breakthrough in the field of surge protection; it is actually the first truly environmentally friendly and sustainable varistor ceramic with such advantages that their production could significantly affect the world market for overvoltage protection. While characterized by comparable or even better current-voltage (I-U) characteristics, the ZnO-Cr_2O_3-based ceramics do not contain the highly volatile Bi_2O_3, expensive rare-earth elements (Pr_6O_{11}) or toxic V_2O_5 than the previously known ZnO-based varistor ceramics, their microstructure is practically single-phase, and the cost of the required varistor dopants is much lower. With the goal to keep the chemical simplicity of the novel ZnO-Cr_2O_3-based varistor ceramics and also low costs of materials, a possibility to replace oxides of Co and Ca with significantly cheaper Mn_3O_4 and more stable MgO was examined.

In recent years, Cr-doped ZnO nanostructures has received much attention due to their interesting properties for applications in various advanced technologies. Cr has a very similar ionic radius to Zn ions and is, as transition metal element, interesting donor dopant for energy band engineering of ZnO nanostructures. Incorporation of Cr-dopant enables applications of ZnO in optoelectronics and, due to ferromagnetism, in spintronics, while with enhanced photocatalytic characteristics the ZnO nanostructures are use in removal of organic pollutants from environment. For ZnO nanostructures synthesized by wet chemical methods (i.e. solvothermal, hydrothermal, sol-gel) at low temperatures, solid solubility of about 3 to 4 at.% Cr in ZnO is reported in the literature. Solid solubility of Cr in ZnO contradicts role of Cr_2O_3 as varistor former in novel ZnO-Cr_2O_3-based varistor ceramics; as varistor former it has to remain in the grain boundary region to create acceptor states and thus electrostatic double Schottky barriers. Much less, however, is reported about Cr-doped ZnO ceramics which is typically synthesized at higher temperatures where $ZnCr_2O_4$ is formed and can affect incorporation of Cr into ZnO. In order to shed light on open questions regarding doping of ZnO with Cr, we studied structural and microstructural characteristics of ZnO ceramics doped with up to 6 at.% Cr.

The results of these preliminary studies will be presented and discussed.

Addressing Microplastic Pollution Through Fungal Biodegradation and ZnO-Based Photocatalysis

In this presentation, I will discuss environmental pollution, illustrated by our discovery of PET fibers in hail, making us the first in the world to report such findings. I will emphasize the urgent need to address microplastic pollution, which we have approached through fungal degradation and photocatalysis. We tested 146 fungal strains exposed to various types of plastic and monitored their metabolism using gas chromatography to detect carbon dioxide production. Our focus was on fungal species found in car repair workshops and hypersaline waters, as most mismanaged plastic waste ends up in such environments.

Furthermore, I will focus on photocatalysis using ZnO. In addition to studying growth parameters to control size distribution, we investigated intrinsic defect populations that could influence the photocatalytic degradation of caffeine. Specifically, we examined how variations in defect concentrations within the ZnO structure affect photocatalytic performance. Our analysis using Raman spectroscopy, photoluminescence, and EPR spectroscopy revealed that defects generated during the recrystallization of ZnO are crucial for photocatalytic activity, whereas surface chemistry plays a lesser role. The results of this study provide new insights into optimizing photocatalytic materials for environmental remediation.

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3D-printed zinc oxide structures for efficient degradation of microplastics in wastewater

Microplastic pollution, primarily originating from synthetic textiles, poses significant environmental and health risks. It enters wastewater through laundering and subsequently affects human health through ingestion, inhalation, and skin contact. While conventional filtration methods can help mitigate its spread, existing wastewater treatment solutions do not address the protentional of the degradation of microplastics. This seminar presents the potential of 3D-printed mesoporous zinc oxide (ZnO) structures as a customizable and efficient alternative to traditional ceramic filters. The goal is to introduce photocatalytic degradation of microplastic and contribute to more sustainable wastewater treatment solutions. The degradation mechanism relies on the photocatalytic process, utilizing abundant light as an energy source to break down problematic waste. Zinc oxide, a semiconducting material, has shown promise in degrading various organic pollutants, making it an ideal candidate for this application. Additionally, designing a filter from such a material, which is environmentally benign, offers a promising approach to breaking down polymer chains into harmless or less problematic by-products.

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Addressing the challenge of microplastics through tailored synthesis of ZnO nanorods arrays for enhanced photocatalytic degradation

Plastics are essential in modern life, but microplastics have emerged as a significant environmental concern. These tiny particles, ranging from 1 μm to 5 mm, originate from various sources and are classified as either primary or secondary microplastics. Of particular concern are microfibres, which are released during washing, drying, and wearing synthetic clothing. Microfibres are estimated to contribute up to 35 % of primary microplastics in the oceans. Microplastic pollution is a pressing issue due to the persistence of plastic particles, their ability to absorb harmful substances, and the release of toxic chemicals during degradation.

In this seminar, we present a critical overview of research on microplastics, focusing on their sources, impacts, and potential reduction strategies. As part of our research, we have prepared ZnO seed layers using a spin-coating technique, followed by the environmentally friendly hydrothermal growth of ZnO nanorod arrays at low temperatures. The impact of synthesis parameters, including precursor solution concentration, calcination temperature of ZnO seed layers, hydrothermal duration, and annealing temperature of ZnO nanorod arrays, on the morphological and structural properties of the ZnO nanorod arrays was systematically investigated. Advanced characterization techniques, including scanning electron microscopy (SEM), transmission electron microscopy (TEM), thermogravimetric analysis (TGA), X-ray diffraction (XRD) and Raman spectroscopy were employed to analyze the structural and chemical properties of the materials. The photocatalytic performance of ZnO nanorod arrays was also evaluated.

Results indicate that the ZnO nanorod arrays exhibit photocatalytic activity, with their performance dependent on synthesis conditions. Furthermore, the ZnO nanorod arrays demonstrated stability and reusability over multiple cycles, highlighting their potential for practical environmental applications. The findings underscore the photocatalytic potential of ZnO nanorod arrays for microplastic degradation; however, further optimization of the material's photocatalytic activity is necessary for practical implementation.