NANO · MICRO small
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Advanced Hybrid GaN/ZnO Nanoarchitectured Microtubes for Fluorescent Micromotors Driven by UV Light

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The development of functional microstructures with designed hierarchical and complex morphologies and large free active surfaces offers new potential for improvement of the pristine microstructures properties by the synergistic combination of microscopic as well as nanoscopic effects. In this contribution, dedicated methods of transmission electron microscopy (TEM) including tomography are used to characterize the complex hierarchically structured hybrid GaN/ZnO:Au microtubes containing a dense nanowire network on their interior. The presence of an epitaxially stabilized and chemically extremely stable ultrathin layer of ZnO on the inner wall of the produced GaN microtubes is evidenced. Gold nanoparticles initially trigger the catalytic growth of solid solution phase $(Ga_{1-x}Zn_x)(N_{1-x}O_x)$ nanowires into the interior space of the microtube, which are found to be terminated by AuGa-alloy nanodots coated in a shell of amorphous GaO_x species after the hydride vapor phase epitaxy process. The structural characterization suggests that this hierarchical design of GaN/ZnO microtubes could offer the potential to exhibit improved photocatalytic properties, which are initially demonstrated under UV light irradiation. As a proof of concept, the produced microtubes are used as photocatalytic micromotors in the presence of hydrogen peroxide solution with luminescent properties, which are appealing for future environmental applications and active matter fundamental studies.

1. Introduction

In the past, intensive research has been performed in the field of photocatalytic materials, predominantly covered by oxides such as TiO_2 and ZnO, oxynitrides or sulfides. These are engineered as single or multiple component nanostructures with potential applications ranging from photoreduction of CO_2, H_2 generation, self-cleaning surfaces, and artificial leaves.[1]

Future trends point to more complex nanoarchitectures by tuning the size, shape, and composition to achieve hierarchically structured nanocomposite photocatalytic semiconductor units.[1]

The fabrication of hollow particles and tubular structures with complex morphologies via template-assisted methods has been demonstrated to come up with exceptional properties for electrochemical energy application.[2] Template-based methods designed toward hollow structures provide high design flexibility and

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DOI: 10.1002/smll.201905141

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