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Light-induced self-cleaning properties of ZnO nanowires grown at low temperatures

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Highly *c*-axis oriented ZnO nanowires' arrays were grown on glass substrates using an aqueous solution approach, in which the growth temperature does not exceed 95 °C in any step of the synthesis. Both their photocatalytic and wetting properties were studied upon ultraviolet (UV) light irradiation. It is revealed that ZnO nanowires' arrays show advanced photocatalytic activity, along with a remarkable reversible photo-induced transition from hydrophobic to super-hydrophilic under UV light exposure, reaching a nearly zero contact angle in short time. The capability to control the morphological characteristics of ZnO nanowires via the deposition of an amorphous seed layer is discussed, which can be significant for self-cleaning applications.

1. Introduction

The self-cleaning mechanism is a unique dual-action property of surfaces. The photocatalytic action, in which the coating reacts with daylight to break down organic dirt, and the hydrophilic action, in which the rainwater spreads uniformly across the surface, takes away the loosened dirt and dries quickly without leaving any streaks. Hence, the synergetic effect of these two actions is quite important in sustaining the self-cleaning effect [1]. Control of the self-cleaning property has attracted great interest because of its importance in fundamental research and industrial fields. Most of these applications involve solid surfaces such as glasses and flexible membranes or even waterproofing textiles [2,3].

Among other materials, the wetting properties of metal oxides, mainly of TiO_2 and ZnO, have been widely studied, since irradiation with UV light may significantly modify their wettability [4–7]. Recent studies revealed that micro- and nano-structures exhibiting hierarchical roughness can be super-hydrophobic [8,9] and reversibly switched to super-hydrophilic [10], opening the way for the construction of the future-generation of smart, self-cleaning surfaces [11].

Furthermore, ZnO and TiO_2 have been widely used as photocatalysts because of their ability to degrade organic dyes [12,13], pesticides [14], human metabolite and priority pollutants listed by U.S. EPA, such as trichloroethylene (TCE), 2,4-dichlorophenol (DCP) etc. [15–18] and organic molecules such as stearic acid (SA) [9,12,19–24] or vapours [25] upon UV irradiation.

Comparing the above metal oxides, one can easily distinguish ZnO for its ability to form nanostructures as well as its advantageous characteristic to transform from rods [10,26] to columns and wires [27]. Besides, it has been reported that ZnO shows better activity than TiO_2 in the photodegradation of some dyes in aqueous solutions since it can absorb more light quanta [28].

According to various approaches [5,10,23,24,29,30], well-oriented ZnO nanowires can be grown on several substrates pre-coated with a highly crystalline ZnO seed layer annealed at high temperatures (usually >300 °C).

In the present work, we investigate the self-cleaning properties of *c*-axis oriented ZnO nanowires grown at 95 °C. More specifically, the photo-induced reversible wetting properties of the as-grown samples, along with the degradation of SA, under UV-A light illumination (365 nm) were studied, in relation to deposition time and their resultant morphological characteristics. The ZnO nanowires'

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