

Functional Metal Oxide Surfaces: Photocatalytic, Self-Cleaning, Sensing, and Micro-/Nanostructuring Applications

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Titanium oxide (TiO₂) is one of the most used photocatalytic materials for various applications such as environmental remediation, (solar)water splitting, and self-cleaning due to its high activity, low cost, high chemical, and physical stability. However, the photocatalytic activity of TiO₂ is limited by the wide energy of the bandgap, low quantum efficiency, and rapid recombination of photogenerated charge carriers (electrons and holes). During the last decades, numerous approaches, such as tailoring the morphology (nanoparticles, thin film, etc.), combining with metal, noble metal, and metal oxide micro/nanostructures, have been demonstrated to enhance the photocatalytic activity of TiO₂. However, it is still a major challenge to find the best photocatalytic combination for specific applications. Recent studies have revealed that particle size plays a considerable role in the photocatalytic activity of TiO₂. Reducing the particle size (increasing active surface area) indicates a higher photocatalytic activity. Nevertheless, the use of photocatalytic nanoparticles in continuous flow systems (such as water remediation, water splitting, etc.) has some practical limitations such as reusing and splitting them up from the reaction media. Hence, the use of robust and stable thin film photocatalysts becomes more suitable rather than nanoparticle systems for practical applications. Nevertheless, thin films are restricted by low surface area in contrast to nanoparticles and they show extremely limited photocatalytic activity. Here we present some case studies on enhancing the photocatalytic performance of TiO₂ thin film by modification with metallic and oxide nanostructures for practical applications such as water purification, self-cleaning, selective oil absorption, and organic molecule sensing.