

Investigating the nanostructural evolution of TiO₂ nanoparticles in the sol-gel derived TiO₂-polymethyl methacrylate nanocomposites

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Abstrak

Nanocomposite thin films consisting of titanium oxide, or TiO₂, nanoparticles embedded in a polymer matrix represent a new class of potential materials for optoelectronic applications such as optical switches, waveguides, high refractive indices and non-linear optical devices. Among the various processing techniques under development for these nanocomposites, the in situ sol-gel process is known to be versatile as it enables control of the inorganic-organic interaction at various molecular, nanometer, and micrometer scales. However, the sol-gel process has a major limitation, which is the low crystallinity in the resulting TiO₂ phase due to relatively low processing temperatures. Therefore, the current research is aimed at investigating the nanostructural evolution of the TiO₂ crystallite during the in situ sol-gel process to gain a better understanding of the mechanisms responsible for the largely amorphous nature of TiO₂ nanoparticles. For this purpose, two sol-gel parameters, i.e., the hydrolysis ratio (R_w) and pH value of the TiO₂ precursor solution were varied. On the basis of XRD and FTIR analyses, it was found that the largely amorphous TiO₂ state is related to the fast development of stiff Ti-OH networks during the hydrolysis and condensation stages of the sol-gel process, and concurrently worsened by the formation of the rigid PMMA matrix upon thermal annealing.