Formation of TiO - Single Crystals in $Ag\text{-}TiO_2$ based Nanocomposites by Swift Heavy Ion Irradiation

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Noble metal nanoparticles embedded in different dielectric matrices are of immense interest due to their potential applications in plasmonics, sensors and antibacterial coatings. The strong absorption of light by noble metal nanoparticles called surface plasmon resonance (SPR) has been the subject of investigation because of their exciting applications in plasmonics and nanophotonics [1, 2]. Tuning the SPR absorption in metal-dielectric nanocomposites is a major issue for which different approaches have been followed [2]. Swift heavy ions (SHI) can be used for controlled tailoring of the nanocomposite properties [3].

In the present work, we report the synthesis of $Ag\text{-}TiO_2$ nanocomposite thin films through vapor phase deposition and their modification by SHI. Co-sputtering of silver together with TiO_2 was used to produce $Ag\text{-}TiO_2$ nanocomposite coatings, where Ag nanoparticles are embedded in TiO_2 matrix. The $Ag\text{-}TiO_2$ nanocomposite films (thickness ~35 nm) with silver-volume-fraction between 10 and 40 wt% were prepared by co-sputtering of Ag and TiO_2 using two different sources. Microstructural and optical properties of nanocomposite films were studied.

Transmission electron microscopic analysis (Tecnai F 30 G^2) reveal that the Ag is crystalline and TiO_2 is amorphous in nature as shown from the inset of figure 1(a). The metal concentration was determined by measurement of the composite film thickness with a profilometer, and subsequently determined by using an energy dispersive X-ray spectrometer (SEM-EDX Philips XL30) [3]. Optical extinction studies reveal the existence of SPR with the peak in the visible regime tunable from 488 nm to 640 nm through UV-Vis spectroscopy.

SHI were used to engineer different properties of nanocomposites. On irradiation with 100 MeV Ag^{8+} ion beam at various fluences of $1x10^{12}$, $3x10^{12}$ and $1x10^{13}$ changes in the optical spectrum like narrowing of the SPR peak, along with associated changes in the particle morphologies have been investigated. The typical TEM image of the nanocomposites with 13 wt% Ag has been shown in Figure 1(a). On SHI irradiation of these nanocomposites, formation of single crystalline TiO has been observed at a particular fluence of 3 x 10^{12} (Figure 1(b)). The formed TiO crystals are of the order of ~ 400 nm in size and confirmed by diffraction studies as can be seen in figure 2. HRTEM images in Figure 3 show clearly the lattice fringes of the TiO crystals in the matrix of the Ag-TiO2 nanocomposites.

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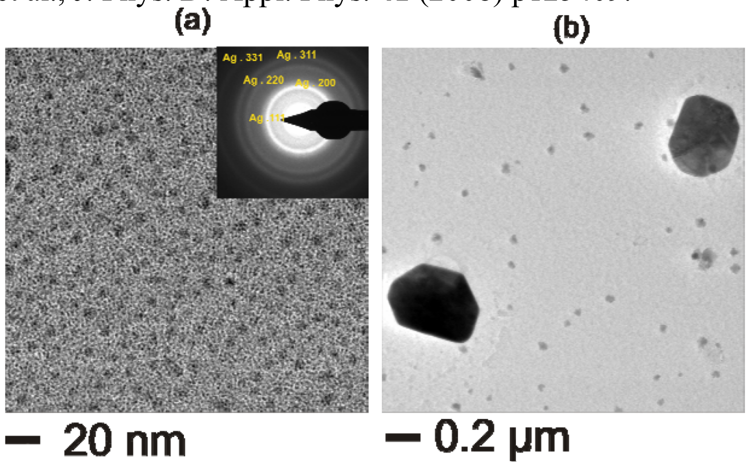

Figure 1. TEM image of (a): Ag-TiO_2 nanocomposite film (13 wt% Ag) showing formation of Ag nanoparticles with an inset of the diffraction pattern (b): Irradiated at 3 x 10^{12} fluence.

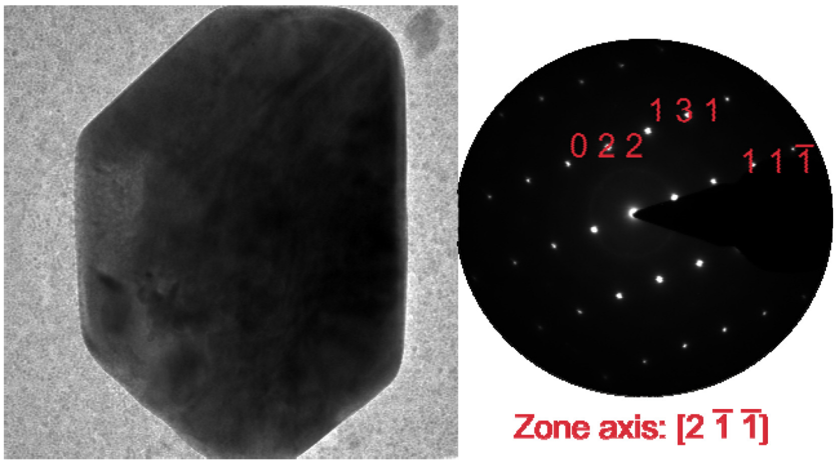

Figure 2. TEM image and SAED of one TiO crystal along the zone axis [2 ī ī].

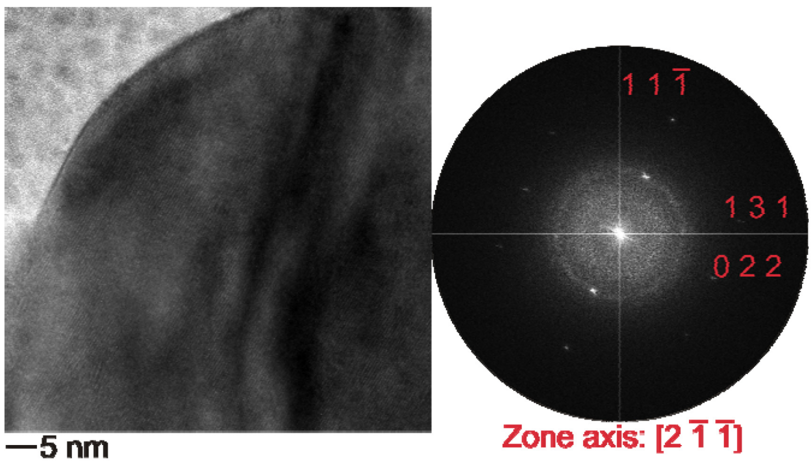

Figure 3. HRTEM and FFT images of the TiO crystal in the Ag-TiO2 nanocomposite along the zone axis [2 ī ī].

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