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Deposition of controlled ultrathin SnO_2:Sb films by self-assembly of Nanocrystals in Organic Solvents

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Abstract – Thin films of transparent conductor oxides (TCOs) have been produced by dip-coating, spin-coating, sputtering and so on. Nanoparticles of Antimony-doped Tin Oxide (ATO) synthesized by the benzilic alcohol method, presents hydrophobic character. Our research group has deposited these ATO nanoparticles under silicon and quartz wafers, which has hydrophilic surface. We look for a deposition method that allows the production of homogeneous and controlled layers of ATO nanocrystals under silicon substrate by self-assembly. The functionalization of the silicon was made with 3-aminopropyltriethoxisilane (APTES). The ATO nanocrystals presented strong interactions with amine groups, which allowed its controlled deposition.

Thin films of transparent conductor oxides (TCOs) have been produced by dip-coating, spin-coating, sputtering and so. A novel method of ultrathin SnO_2:Sb films of nanocrystals (NC) in organic solvents deposition has been developed in this study. In the first step, the silicon wafers were functionalized with 3-aminopropyltriethoxisilane (APTES) [1] or 3-isocyanatepropyltriethoxisilane (IPTES), which yields a surface free of amine or isocyanate groups. The second step consist of two different ways to attach the ATO NC on the modified silicon surface: The first one is the functionalization of the ATO NC with APTES, thus the assembly on the substrate can be made through urethane reaction. The second way regards the use of the surface characteristic that ATO NP has to interact strongly with amine groups due to its benzilic alcohol synthetic route [2], so the nanoparticles can be deposited on the modified substrate without any pre-treatment.

At first, a cleaning and activation treatment with piranha solution ($3H_2SO_4$:$7H_20_2$) were performed in the silicon wafers. The fresh cleaned substrates were functionalized with 1mmol APTES solution of toluene in a glove box under a controlled atmosphere. One might note that a visual superficial modification occurs, as can be seen in Figure 1. A 0.4 $g.L^{-1}$ ATO NP colloidal dispersion (using tetrahydrofuran as organic solvent) was used on the modified silicon surface.

Atomic Force Microscopy (AFM) revealed a notable difference in the grains size after ATO NP deposition. Thus, analyzing Figure 2 and 3 it's possible to note that the ATO NCs were deposited on the silicon surface. The grains, as presented in Figure 3, are in the size range of 7-9nm. Further investigation will be carried out in order to confirm whether the ATO NP were deposited homogeneously or not, in positive case we can conclude that the drawback between hydrophilic and hydrophobic surfaces was overcome. A comparative spectrum of infrared (FT-IR) between ATO NP, ATO NC modified with APTES (ATOAPTES) and APTES exposed in Figure 4, indicates the success of the functionalization. A band from 900 to 1130cm^{-1} in the ATOAPTES shows the formation of the bonds Si-O-M and Si-O-Si. A weak band in 3386,912cm^{-1} in the same specimen indicates the presence of amine group from APTES.

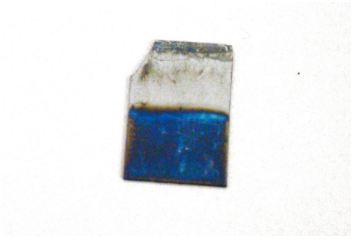

Figure 1: Pos-modified silicon wafer.

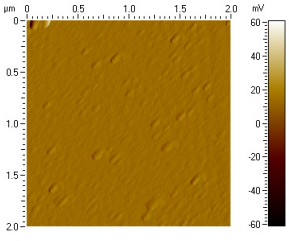

Figure 2: AFM picture of silicon.

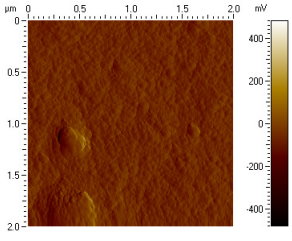

Figure 3: AFM picture of silicon ATO deposited.

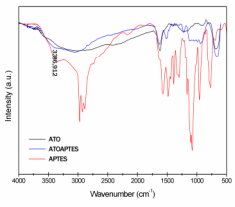

Figure 4: FT-IR spectrum of ATO, ATOAPTES and APTES.

References

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