Photo-induced super-hydrophilic anatase thin film fabricated *via* electrospray deposition from molecular precursor solution onto a quartz glass substrate

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1. Introduction

Electrospray deposition (ESD) is one of the processes for thin film fabrication from high voltage induced-sprays. By supplying the precursor solution through a metallic capillary maintained at high electric potentials, the deposition of sprays droplets on the substrate attached to a grounded electrode plate are possible [1]. The ESD process can be carried out at room temperature and atmospheric pressure and has been used for fabrication of metal oxide thin films on a conductive substrate [2]. However, there is no report for the fabrication of metal oxide thin films on an insulating substrate *via* the ESD process, as far as we know. Jawareck and co-authors reported that its difficulty to fabricate thin films on insulating substrates due to charge accumulation, repelling oncoming droplets during fabrication [3].

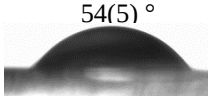
We here report the precursor film fabrication *via* an ESD process on a quartz glass substrate modified with the ultra-thin single-wall CNT (SWCNT). Anatase thin films were obtained by heat treating the precursor films and characterized precisely.

2. Experimental

The quartz glass surface was modified before fabrication by an SWCNT ultra-thin film obtained *via* spin coating 0.005 mass% of SWCNT solution (KH OS ET–DOO2, KH chemicals Co., Ltd.). A molecular precursor solution of TiO_2, which involves Ti^{4+} complex salt of 0.10 mmol g^{-1}, was electro-sprayed on the SWCNT pre-coated quartz glass substrates. The precursor film obtained was heat-treated at 500 °C in air for 1 h. The resultant thin film was denoted as **F'$_C$**. The molecular precursor solution was also used to fabricate anatase thin films by using a spin-coating procedure, directly on the identical substrate according to the reported one by Sato *et al*. [4], and the resulting thin film was denoted as **F'$_{Qspin}$**. The results on the spin-coated thin film were compared to those of the ESD thin film.

The XRD patterns of all thin films suggest that all the crystals on the quartz glass substrate are assignable to anatase. The film thicknesses of the thin films, **F'$_C$** and **F'$_{Qspin}$** are 90 and 100 nm, respectively. All the thin films are transparent and exhibit optical transmittance over 85% in the visible region. The optical band gap of the **F'$_C$** and **F'$_{Qspin}$** calculated from Tauc plot equation is 3.62 and 3.64 eV, respectively.

Table 1 Water contact angle of the thin films before and after irradiating for 1 h of UV light whose intensity at 365 nm is 4.5 mW cm^{-2}.

Thin films	Before UV irradiation	After UV irradiation
F'$_C$	14(2) ° 	1(1) ° 
F'$_{Qspin}$	54(5) ° 	12(3) ° 

The refractive index of the **F'$_C$** and **F'$_{Qspin}$** thin film is 2.15 and 2.07 respectively, as a reference to quartz glass substrate. The water contact angle of the **F'$_C$** and **F'$_{Qspin}$** thin film before UV irradiation was 14(2)° and 54(5)°, respectively. After UV irradiation for 1 h, the water contact angle of the **F'$_C$** and **F'$_{Qspin}$** decreased to 1(1) ° and 12(3) °, respectively. In addition, the AFM, Raman, and XPS of the thin films will also be discussed.

3. Conclusions

A useful procedure for fabricating precursor thin film of anatase on a quartz glass substrate *via* the ESD process was developed by pre-coating an ultra-thin SWCNT film on the insulating quartz glass substrate. Consequently, a photo-induced super-hydrophilic anatase thin film of 90 nm thickness could be obtained by heat treatment of the precursor film at 500 °C in air for 1 h.

References

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