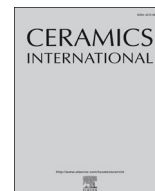




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Hydrophobicity and transparency of Al₂O₃-based poly-tetra-fluoro-ethylene composite thin films using aerosol deposition

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ABSTRACT

Alumina and polytetrafluoroethylene (Al₂O₃-PTFE) composite films were fabricated by a simple aerosol deposition (AD) process, to confirm its applicability for various display screens requiring water resistant, anti-smudge and easy-to-clean properties. The surface morphologies, hydrophobic properties, and transparencies of the composite films with different PTFE contents, varying from 0.01 to 1 wt% were investigated. As a result, the composite films with over 0.3 wt% PTFE showed a sudden rise in surface roughness and low transmittance, despite having the highest contact angle of 128° at a PTFE content of 0.3 wt%. From the energy dispersive spectrometer analysis, the crash-cushioning effect of PTFE and agglomerated PTFE particles were determined to be major causes of surface roughness and opacity. In contrast, the transmittance showed a tendency to be enhanced, with an increasing PTFE content in the range of 0.01, 0.05, and 0.1 wt% PTFE, respectively. Especially, the film with 0.1 wt% of PTFE had contact angle of 111° and exhibited a high transmittance of over 75%, which was inferred to be an appropriate amount of PTFE, with a high elongation filling up the surface and the internal defects, leading to an enhancement of transparency. Consequently, these results implied that the AD-prepared Al₂O₃-PTFE composite coatings are promising candidates for various display applications.

1. Introduction

Recently, as the performance of various electronic devices has improved, the technologies that can control the characteristics of the surfaces are required. Among them, since super-hydrophobic surface treatment is very important to improve the stability and reliability of electronic devices, many researchers in various industries are continuously attempting to study super-hydrophobic surfaces [1–5]. Especially, the properties of anti-wetting by super-hydrophobic coatings are desired in applications for high value-added semiconductor products such as display, printed circuit board (PCB), micro-electro-mechanical systems (MEMS). When droplets roll over a super-hydrophobic surface, self-cleaning action occurs [6], which removes and prevents foreign substances on the surface. Basically, the behavior of liquids on a solid surface is determined by the geometric structure and chemical composition of the surface [7,8]. Moreover, combining a material having a low surface energy with a nano structure surface, a super-hydrophobic surface can be formed [9].

In the study of V. Skrozniakova, silica films were prepared by using the sol-gel method on float glass substrates. Samples with silica coatings were treated at different temperatures ranging from 300 °C to 450 °C. In their study, a transmittance of 91.7% and a contact angle of 120° were achieved [10]. Also, Cheng Sun et al. fabricated super-hydrophobic film with dual-size roughness using an electrostatic adsorbing method and template-directed self-assembly [11]. By measuring the contact angle and sliding angle, they analyzed the effect of dual-size roughness on water wetting and achieved a maximum contact angle of 166°. However, to fabricate a super-hydrophobic surface by these processes, complicated deposition and a high-temperature annealing process are inevitable to form hydrophobic coating films. When the process is carried out at a high temperature, evaporation or changes in chemical composition occurs, and the bonding strength with the substrate is also weak. In addition, conventional processes have many drawbacks such as high process cost and slow coating speed due to the complicated nature of the process.

On the other hand, these shortcomings can be solved by using an

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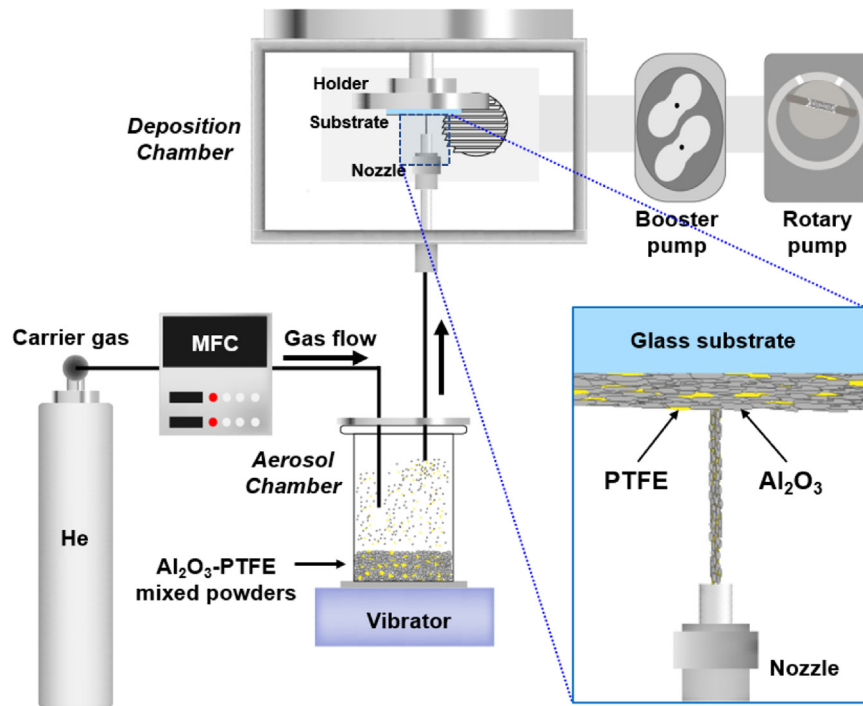


Fig. 1. Schematic diagram of AD equipment.

Table 1

Experimental parameters of an aerosol deposition process.

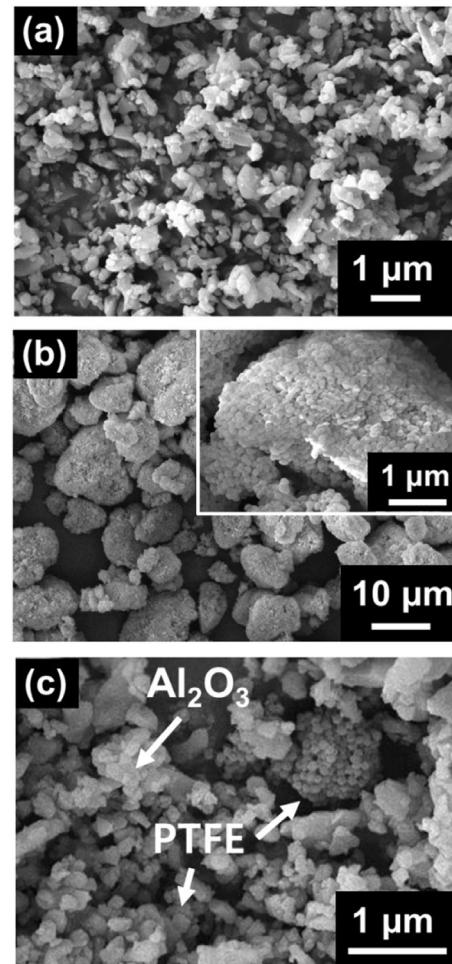
Starting powder	Al ₂ O ₃ -PTFE
Substrate	Glass
Carrier gas	He, N ₂
Consumption of carrier gas	3–5 L/min
Scanning area	20 × 20 mm ²
Working pressure	3.2 Torr
Size of nozzle orifice	10 × 0.4 mm ²
Distance between substrate and nozzle	5–10 mm
Deposition temperature	Room temperature
Deposition time	10–30 min
Vibration speed	400–500 rpm

aerosol deposition (AD) method enabling room-temperature processes, a low vacuum system, and over a wide range thickness control for fabricating films. Also, the AD process can be used to fabricate composite films using heterogeneous materials and to produce films with high densities. Moreover, there are advantageous in terms of time and cost, because we can very rapidly fabricate a coating layer with an organic hydrophobic surface. Therefore, we attempted to form composite thin films with hydrophobic properties and high transparencies for application of transparent electronic display devices through a simple AD process.

In this study, polytetrafluoroethylene (PTFE) with hydrophobicity and alumina (Al₂O₃) with high hardness were chosen as the mixed starting powder [12], in order to fabricate transparent and dense Al₂O₃-PTFE composite films with hydrophobicity by AD process [13]. Addition of PTFE conferred hydrophobic properties to alumina (Al₂O₃) enabled coating of surfaces that were hard and effectively transmitted light. Then, Al₂O₃-PTFE composite films with different portions of PTFE in Al₂O₃ were prepared and investigated their surface microstructures and roughness, contact angles, and transmittances, considering deposition mechanisms.

2. Experimental procedures

Alumina oxide (α -Al₂O₃) powders and polytetrafluoroethylene

Fig. 2. Plane-view SEM images of each material (a) Al₂O₃ powder (b) PTFE powder (c) And Al₂O₃-PTFE composite powder.

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