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Room Temperature Photochemical Fabrication of Silica Glass Coatings using Vacuum Ultraviolet Excimer Lamps

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1. Introduction

Recently it becomes possible to fabricate silica glass coatings onto various kinds of materials by heating coated polysilazane films ; $(\text{-SiH}_2\text{-NH-})_n$ [1-3]. This technique attracts much interests in wide area of industry for making protective hard coatings, electrical insulating layers, thermal or chemical resistive films, highly transparent or anti-reflection coatings, and gas barrier coatings. To produce high quality silica glass coatings from the polysilazane precursor, heating processes above 600 C° are necessary to remove residual nitrogen atoms or Si-OH impurities. Lowering of the process temperature is necessary for fabricating high quality silica glass coatings onto thermally unstable substrates such as plastics or semiconductive devices.

In this paper, we demonstrate a room temperature photochemical fabrication of silica glass coatings by utilizing a vacuum ultraviolet (VUV) light irradiation obtainable by recently developed high power xenon excimer lamps. The quality of the photochemically fabricated coatings are elucidated here by spectroscopically investigating their chemical structures, and compared with the thermally fabricated coatings.

2. Experimental

Polysilazane solutions, used as received from Clariant Japan without further purification, were diluted with toluene, and spin-coated onto Si (100) substrates (10 x 10 x 0.5 mm, both sides polished). The Si substrates are carefully wiped with ethanol, and then photolytically cleaned by the VUV irradiation just before using. Spin-coating was performed at 1500 rpm for 120 s, yielding film thicknesses ~ 500 nm after drying onto a hot plate at 50 C° for 10 minutes.

A xenon excimer lamp (Quark Systems, QEX-230SX, 172 nm, ~8 mW/cm^2) was employed to irradiate VUV light on the sample. Irradiation time was about 1 hour. The lamp was placed within a small stainless chamber together with the polysilazane-coated Si substrate, and then filled with atmospheric pressured dry air at ~5 l/min flow rate. The distance between the lamp and the Si substrate was kept about 2 ~ 3 mm.

A quartz tube muffle oven (Asahi Rika ARF-50K) was used to thermally fabricating the coatings. In this case, samples were kept heated in air for about 1 hour.

An X-ray photoelectron spectrometer (Ulvac-Phi PHI-5500) was used to measure the X-ray photoelectron spectra (XPS) with aluminum Kα X-ray source. An FT-IR spectrometer (Shimadzu FTIR-8200PC) was used to obtain infrared (IR) absorption spectra with wavenumber resolution of 4 cm^{-1}.

3. Results and discussion

3.1 XPS spectra

Figure 1 shows Si2p, N1s and O1s XPS spectra of thermally (a-f) or photochemically (g) fabricated coatings from polysilazane, respectively. XPS spectra give information about atomic concentrations and chemical bonds at the surface (1 ~ 4 nm depth). As shown in the fig. 1(a-f), chemical shifts toward higher binding energy were

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