Formation of Functional Ceramic Films with Ultrafine Particle Beams

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1. Introduction

Piezoelectric lead zirconate titanate [PZT : ($Pb(Zr_{052},Ti_{0.48})O_3$)] is utilized for sensors and actuators in micro electromechanical systems[1]. Anatase type titania (TiO_2) is a photocatalyst[2] and has antibiotic and deodorization properties. In this study we have developed deposition technology for these functional ceramics on stainless steel plate using ultrafine particle beams[3].

2. Experimental conditions

As shown in Fig. 1, a film fabrication system for ultrafine particle beams is mainly composed of an aerosol chamber and a processing chamber connected by Teflon tube. There is a pressure difference between both chambers since the processing chamber is pumped down with a mechanical booster pump and a rotary pump. Helium gas flows from the aerosol chamber (higher pressure) to the processing chamber (lower pressure). Ultrafine particles of functional ceramics are set in the aerosol chamber. They are accelerated by the helium gas flow and carried to the processing chamber through the Teflon tube and nozzle. After the ultrafine particles are ejected from the nozzle, they impact the substrate and deposit on the surface of the substrate. Functional ceramics film could be produced by this deposition process. Average diameters of PZT and TiO_2 particles we used were 420nm and 250nm, respectively. Each particle cohesion was modified with a ball mill machine prior to the experiment. The nozzle employed in this experiment was made from stainless steel (SUS316) pipe and had an opening of 5.7mm x 0.5mm. Substrate material was stainless steel (SUS304). The distance between nozzle and the substrate surface was 5mm. In each experiment, using PZT or TiO_2 particles, the pressure difference was 0.6atm and ultrafine particle beams were scanned accross the surface of the SUS304 plate in an area of 5.7mm x 5.0mm for 5minutes.

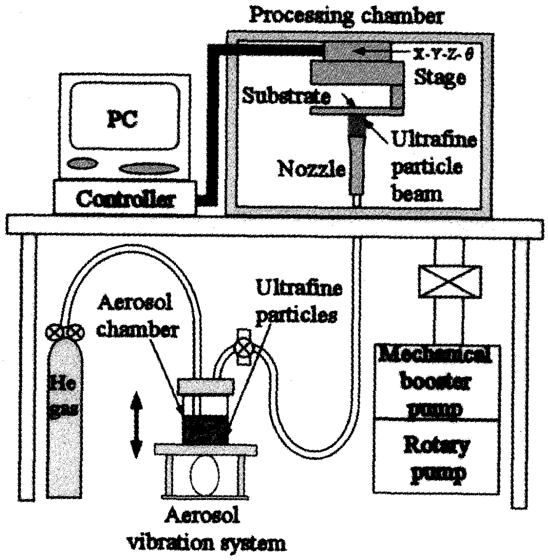

Fig. 1 Schematic configuration of the material processing system for ultrafine particle beams

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3. Experimental Results

Typical films fabricated by ultrafine particle beam irradiation are shown in Fig. 2. Figures 2(a) and 2(c) show the surface of PZT and TiO_2 films, respectively. These photographs indicate that each film was produced in the nozzle scanning area. Cross sections of both films are shown in Fig. 2(b) and 2(d).

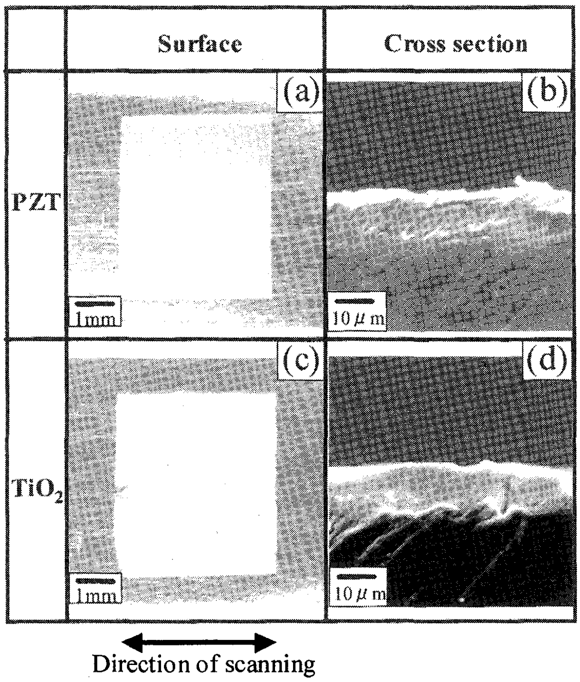

Fig. 2 Surface photographs and cross section images of PZT and TiO_2 films

Each image was observed with a scanning electron microscope. As Fig. 2(b) and 2(d) show, the thicknesses of PZT and TiO_2 layers were circa 10 μm. To investigate the adherence strength between PZT or TiO_2 and SUS 304 plate, tensile tests were performed. Results of this test indicated that adherence strength was circa 10MPa at least for PZT or TiO_2 case.

4. Summary

We have developed for PZT and TiO_2 films a fabrication system using ultrafine particle beams. Experimental results indicated that 10 μm thick layers of PZT and TiO_2 were produced in the area of 5.7mm x 5.0mm on the stainless steel plate in 5minutes.

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Reference

1)J. Akedo, M. Ichiki, K. Kikuchi and R. Maeda, Jet molding system for realization of three-dimensional micro-structures, Sensor and Actuators A 69 (1998), 107-112

2)A. Fujishima, The Japan Society of Applied Physics, Vol. 64, No. 8 (1995), 803-807 (in Japanese)

3)E. Fuchita, kinzoku, Vol. 70, No. 6 (2000), 27-37 (in Japanese)