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Short Communication

Micromachining and microdeposition of polytetrafluoroethylene by synchrotron radiation[†]

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Abstract

Polytetrafluoroethylene (PTFE) films deposited on a select area in a microscale were easily etched by employing synchrotron radiation beam very rapidly through a metal mesh mask at room temperature.

Keywords: Micromachining, microdeposition, polytetrafluoroethylene, synchotron radiation.

1. Introduction

Microsystem technology is receiving attention lately creating new fields of application. Many new smart materials and sensors have been proposed and investigated, and many processing methods for ultrafine fabrication have been developed. The LIGA (lithographie, galvanoformung, abformung) process is the most well known. It was developed by using synchrotron radiation (SR).[1–4] Microstructures are successfully fabricated with high aspect ratios (lithography, galvanoforming and plastic moulding) by using the LIGA method. In future ULSI technologies, X-ray lithography will find wide application employing SR beam and it has been developed well in the last few decades.

Polyfluorocarbon polymers, especially polytetrafluoroethylene (PTFE), have excellent properties and have been widely used for a long time. They are stable at high temperatures, but are not easy to fabricate on a microscale. Recently, it has been found that vacuum ultraviolet light in the SR beam will help in microprocessing of these materials in small scale at a very high rate and even at room temperature. [5–7]

In this paper, we report the deposition of PTFE on a small select area by SR beam and etching of the film.

2. Experimental

Strong white light (from X-ray to infrared) is emitted from highly accelerated electrons in intense magnetic fields. The synchrotron radiation beam at UVSOR, IMS (Institute for Molecular Science), Okazaki, Japan, was used in this experiment. The acceleration energy of the electron was 750 MeV, and the wavelength of the white light at BL-8A port ranged from X-ray to infrared. The electric current for this SR emission was varied from 100 to 150 mA. Commercially available

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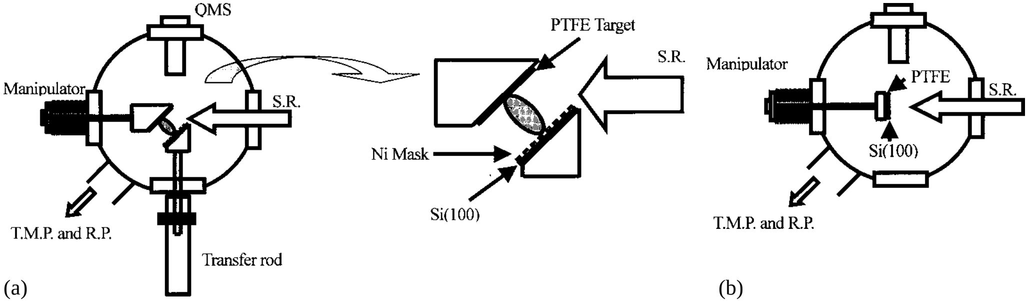

FIG. 1. Experimental set-up for (a) deposition and (b) etching.

PTFE target sheet was used in the reaction chamber (Fig. 1(a)). The distance from the target to the substrate was 30 mm, and the chamber was evacuated to less than 10^{-6} torr. The SR beam was incident to the PTFE target, ablating its surface. PTFE films were deposited through an Ni mesh mask with a hole of 7.5×7.5 μm on the substrates of Si(100), glass and metal. The substrate temperature was varied from RT to 483 K. To etch the PTFE films, another arrangement in the reaction chamber had to be made (Fig. 2(b)). The SR beam was incident through the same Ni mesh mask on the PTFE films. We explored etching after the PTFE films were deposited.

3. Results and discussion

PTFE films were easily deposited from a commercially available PTFE target by using SR beam (Table I). It took only 20 s. The deposition of PTFE was observed through the hole of metal mesh mask on the selected area of the substrate surface (Fig. 2). We ensured that the deposited films were of PTFE. In the XRD patterrns, a very strong sharp peak due to (100) plane of PTFE was observed, indicating that crystalline quality had been obtained and the amorphous part in the films had decreased. In the FTIR observation, main peaks came from CF_2 bonding and a small peak from CF_3 was found. ESCA (electron spectroscopy for chemical analysis) ensured C and F peaks only and there was no trace of impurities. The deposited surface was smooth from AFM (atomic force microscope) observation.

The etching of PTFE films was done by SR-assisted process. Using the same metal mesh mask, the SR beam was introduced to the PTFE flat films deposited earlier. Table II shows the experimental conditions for the deposition of the films and the etching of these samples. Figure 3 shows the SEM images of the etched surface. The PTFE was easily etched only on the area exposed to the SR beam. It was possible to deposit the PTFE films and etch them on a microscale by using SR beam.

Table I
Experimental conditions for deposition

Beam current	110 mA
Temperature (Target and substrate)	Room temperature
Deposition time	20 s

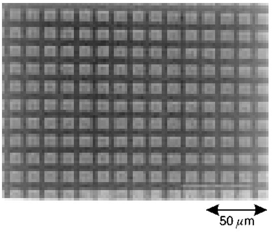

FIG. 2. SEM images of selected deposition of PTFE.

Table II
Experimental conditions for deposition and etching process

Deposition		Etching	
Beam current	180 mA	Beam current	150 mA
Deposition time	20 s	Etching time	2 min
Temperature (Target and substrate)	Room temperature	Temperature (Target and substrate)	Room temperature

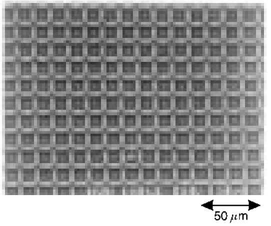

FIG. 3. SEM images of etched surface of PTFE film.

4. Conclusion

Crystalline PTFE films were deposited with a small amount of amorphous part by using SR beam. The deposition rate was very fast even at room temperature. Etching was also easy. Although the LIGA process is well known, the SR-assisted processing method is promising for micromachining and microdeposition of PTFE. It also has simple experimental arrangement.

Acknowledgements

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References

1. BECKER, E. W. *et al.* *Microelectronic Engng*, 1986, **4**, 35–56.
2. HARMENING, H. *et al.* *Proc. IEEE MEMS '92*, 1992, 202–207.
3. BURBAUM, C. *et al.* *Sensor Mater.*, 1991, **3**, 75–85.
4. HIMMELHAUS, M. *et al.* *J. Micromech. Microengng*, 1992, **2**, 196–198.
5. KATO, T. AND ZHANG, Y. *Appl. Phys. Lett.*, 1996, **68**, 865–867.
6. ZHANG, Y. AND KATO, T. *Jap. J. Appl. Phys.*, 1996, **35**, L186–L188.
7. INAYOSHI, M. *et al*. *J. Vac. Sci. Technol. B*, 1999, **17**, 949–956.