2J13

Thermal Diffusivity of Shape-Anisotropic Polyimide Particles by Solid-State Polycondensation of Monomer Salt Single Crystals

Hiroki Fujisawa[1], Meguya Ryu[3], Cerron-Infantes Daniel Alonso[2], Unterlass Miriam[2], Shinji Ando[1], Junko Morikawa[1]
([1]School of Materials and Chemical Technology, Tokyo Inst. Technology, 2-12-1, Meguro-ku Tokyo 152-8550, Japan, [2]University of Konstanz, Germany, [3]National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba 305-8563, Japan)
[1]Tel&Fax: +81-3-5734-2497, E-mail: ando.s.aa@m.titech.ac.jp, morikawa.j.aa@m.titech.ac.jp

Introduction

Poly(p-phenylenepyromellite imide) (PPPI), a crystalline polyimide (PI) particle, is a shape anisotropic polymer obtained by solid-state polycondensation (SSP) of monomer salt (MS) single-crystals of *p*-phenylenediamine (PDA) and pyromellitic acid (PMA). [1] In general, the polymer chains of PI films are aligned in the in-plane direction, so the thermal diffusivity in this direction is higher than that in the thickness direction. [2] On the other hand, the crystal structure of MS of PPPI suggests that the polymer chains are aligned in the thickness direction. Therefore, the anisotropy of thermal diffusivity of MS and PPPI was measured with the micro-scale temperature wave analysis (μTWA) method [3] using a microscale temperature sensor fabricated by MEMS technique.

Experimental

Fig. 1 shows the fabrication procedure of the thermo-electromotive force micro temperature sensor. The circuit pattern was precisely fabricated on a photomask by a laser writing system, the pattern was transferred onto a glass substrate by a mask aligner, and the circuit was fabricated using a lift-off process. These sensors and ITO thin film heaters were placed on the both sides of the sample. The sensors were connected to a lock-in amplifier to detect the phase delay and amplitude of the temperature wave propagating through the sample.

Result and Discussion

Fig.2 is a reflection micrograph of the sample set for thermal diffusivity anisotropy measurement. The thermal diffusivity in the thickness direction (⊥) (*c*-axis) is higher than that in the in-plane direction (//) for both MS and PPPI, but, the anisotropy ratio after SSP(⊥///) is higher for PPPI than for MS. (Table 1)

References

[1] K. Kriechbaum, D. A. Cerrón-Infantes, B. Stöger and M. M. Unterlass, *Macromolecules* **48**, 8773-8780 (2015) [2] J. Morikawa and T. Hashimoto, *J. Appl. Phys.* **105**, 113506 (2009) [3] M. Ryu, S. Takamizawa, J. Morikawa, *Appl. Phys. Lett.* **119**, 251902 (2021).

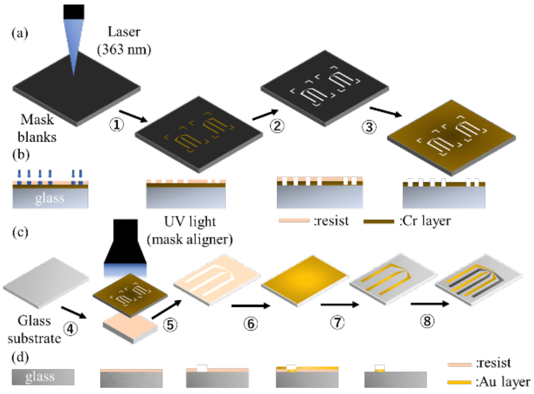

Fig.1 The fabrication process for (a)(b) photomask and (c)(d) micro-scale temperature sensor,①developing, ②Cr etching, ③Resist removal, ④Resist coating, ⑤developing, ⑥ deposition or sputtering, ⑦lift off, ⑧processes for another metal circuits.

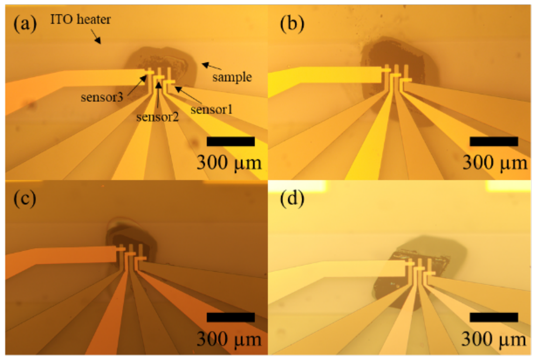

Fig.2 Reflection microscopic images of the samples of (a) PPPI crystal, and (b) MS for out-of-plane measurements, (c) PPPI crystal, and (d) MS for in-plane measurements.

Table. 1. Thermal diffusivity and thermal diffusivity anisotropy of PPPI and MS crystals, measured with μTWA method.

sample	$\alpha/10^{-7}$ $m^2 s^{-1}$	$\alpha_\perp/\alpha_{//}$
PPPI ⊥(Fig.2(a))	10.8±0.02	6.51
PPPI // (Fig.2(c))	1.66±0.07	
MS ⊥(Fig.2(b))	6.21±0.25	2.68
MS // (Fig.2(d))	2.32±0.07	