RESEARCH INTO THE MECHANICAL PROPERTY TEST OF THE PDMS SOFT MOLD UNDER DIFFERENT CONDITIONS ON SOLID STATE SU8

[1]YUNG-JIN WENG, [2]CHENG-HUNG HSUEH, [3]PO-WEI HUANG

Department of Mechanical and Energy Engineering, National Chiayi University, No.300 Syuefu Rd., Chiayi City 600, Taiwan (R.O.C.)
E-mail: yjweng@mail.ncyu.edu.tw(Y-J Weng)

Abstract - This research tests the mechanical properties of solid state SU8 under an different condition Polydimethylsiloxane (PDMS) soft mold, designs one set of Pin on Disk friction tester, uses curing agents of different proportions and material components of PDMS (1:10, 1:5) as the main agent composite proportion as a means of pressure load end, and conducts research into the mechanical property testing of solid state SU8 with different pressure load, while ANSYS simulation is used to provide related data for mechanical property testing to coordinate verification. The experimental results show that, the greater the ratio between curing agent and resist agent, the better the mechanical property and the stronger the strength of PDMS testing with different proportions of curing agent, main agent composite, and mechanical property of SU8; in terms of friction testing, the composite proportion of PDMS 1:5 to the wearing of SU8 is higher than 1:10 and presents a linear trend, which is the same as the simulation. The results of this research will provide a reference basis for microsystem processing in the process of implementation.

Keywords - Mechanical property, PDMS, SU8, Friction test, Tensile test.

I. INTRODUCTION

Plastic is often used as the raw material in the process of microsystem development, as it is light weight, does not rust, and its strength is not inferior to nonferrous metal. Plastic material has toughness and non-electrical conductivity, and the energy it requires during processing is less than iron metal or nonferrous metal. Some plastic materials have a glass transition temperature, meaning shaping operations can be conducted when heated to a certain temperature, giving it the advantages of saving energy and time, thus, it is widely used in academic and industrial applications. With the rapid development of science and technology, manufacturers make various technological components that are light, thin, short, and small as their design and manufacturing objectives, and such microsystem components can be applied to numerous kinds of technological industries, thus, it is closely related to biomedical science and technology, intelligent micro-machines [1-2], photoelectric science and technology [3-5], medical engineering, space technology [6], and material technological industries.At present, global industries tend to rapidly develop miniaturized technologies; in addition to technological innovation, another demand is the rapid integration of manufacturing technologies. Among them, the Lithographie Galvanoformung Abformung (LIGA)[7-10] micro-machine processing technology is an optical lithography process with X-ray to carry out lithography; and LIGA-like technology, which uses non-X-ray (such as ultraviolet light) to carry out the optical lithography process; both integrate the optical lithography process [11-15], electrochemical electric cast technology, mold shape technology, and related process technologies, which are used to realize microelectromechanical (MENS) components or nano electromechanical system components (NEMS). Research has continuously developed the application of microsystem components in recent years, such as, electronic paper, smart card, and flexible display, which have the ability to use low temperature processes to realize large-scale effective transistors with flexible structures. Zhang et al. [16] successfully used ultraviolet transfer printing technology to transfer a printed organic thin film transistor on an elastic mold in 2007 to make an Organic field-effect transistor (OFET) with a groove size of only a few microns; however, the surface roughness of the finished product will affect its performance in the process of realization. As Polydimethylsiloxane (PDMS) material is often used as a soft mold in the microsystem process, the friction phenomenon often appears in the forming process of the drawing mold, which promotes surface roughness of the finished product, thus, thisresearch aims to test the mechanical properties of the PDMS soft mold under different conditions on solid state SU8, in order to understand the change of surface roughness on the finished product, as caused by the friction phenomenon, which is often neglected in industrial production processes, but it is a very important part.

II. EXPERIMENTAL

A. Design and Manufacturing of Pin on DiskFriction Test System

This research develops and designs a Pin on disk friction test system, as shown in Figure 1. This test system mainly includes: air pressure source (Control), power driving part, friction ball head (Pin), friction plate (Disk), and an RPM/time recorder. Among them,

the friction ball head uses PDMS for ball head (Figure 2) production, which is installed as the active end, while the other friction end is placed on the friction plate, which mainly uses the rotation coating method of SU8 to control the thickness required by the experiment (Figure 3), and after curing by ultraviolet light, the SU8 resist agent is applied.

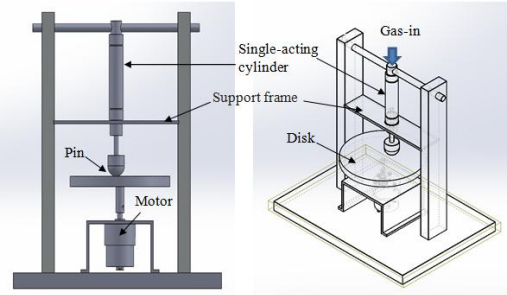


Figure 1. Pin on disk friction test system

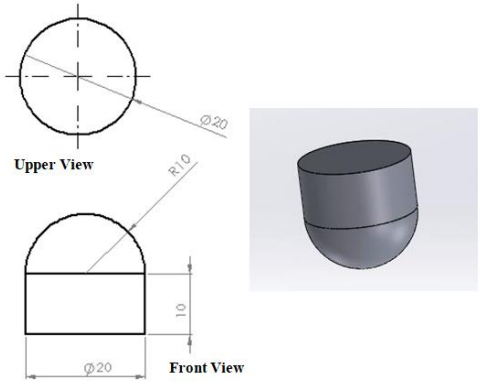


Figure 2.Pin on disk friction test system friction ball head

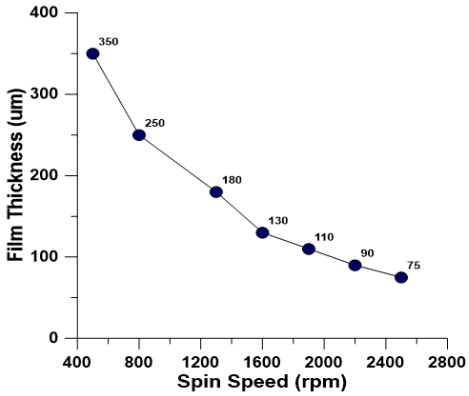


Figure 3. SU8 rotation coating speed and thickness relation diagram

B. PDMS Modulation, Selection of SU8 Resist Agent and Ultraviolet System

This research uses the drive end of the PDMS friction ball head to apply different composite ratios (the ratio between main agent and curing agent is: 1:10, 1:5) for manufacturing. In addition, the selection of resist agent adopts the SU8 ultraviolet consolidated light resist agent, which has good mechanical properties and chemical stability; meanwhile, this research uses an array ultraviolet system to carry out the curing action on SU8, as shown in Figure 4.

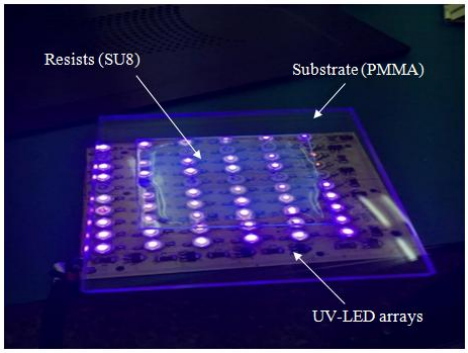


Figure 4. Curing action of array ultraviolet system on SU8

C. Mechanical property test of material and relative friction coefficient analysis

This research uses a micro-tensile testerproduced by the Instron Company to test the tensile mechanical property of PDMS in order to obtain young's modulus, the tensile hardness of materials, and related tensile property parameters of PDMS under different composite proportions; in addition to providing the parameters required in the simulation process, preliminary experimental conditions can be provided for judgment. Moreover,thisresearch conducts analysis on the maximum static friction coefficient of PDMS corresponding to SU8; this section sets up a friction coefficient analysis system (Figure 5), and the relative maximum static friction coefficient is obtained with PDMS under different composite proportionsas experimental conditions.

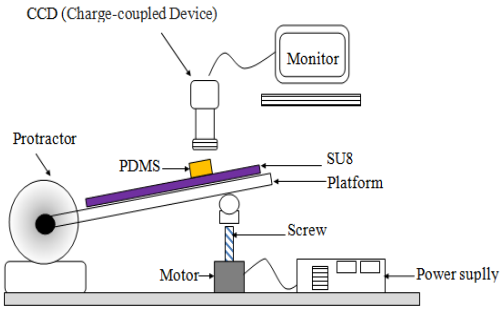


Figure 5. Friction coefficient analysis system

III. RESULTS AND DISCUSSION

A. Tensile Test Influence of PDMS Soft Mold Material with Different Composite Proportion

This section uses different composite ratio (the ratio between main agent and curing agent is: 1:10, 1:5) at room temperature (23°C) to test its mechanical properties through tensile testing. The experimental results show that the higher the ratio between the main agent and the curing agent, the stronger the mechanical properties of the tensile test (Young's modulus, tensile stiffness).

B. Analysis on Maximum static Friction Coefficient of PDMSSoft Mold with Different Composite Proportion Corresponding to SU8

This section uses the maximum static friction

coefficient of the PDMS soft mold with different composite proportions corresponding to SU8 for analysis. The experimental results show that the maximum static friction coefficient of the PDMS soft mold with a low compositeratiocorresponding to SU8 will increase, as shown in Figure 6.

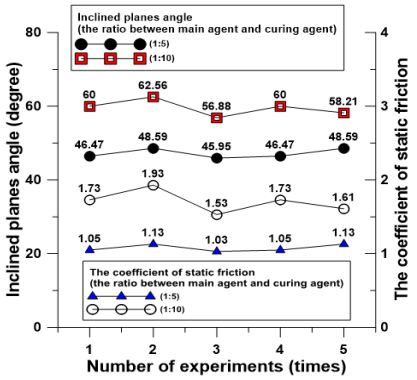


Figure 6. Maximum static friction coefficient analysis on SU8 corresponding toPDMS of different composite proportion

C. Influence of Different Composite Proportion on SU8 Friction Test Experiment

This section uses different composite ratios (the proportion of main agent and curing agent is: 1:10, 1:5) at room temperature (23°C) to test the mechanical property through friction.

After friction tests of Pin on Disk during 2, 4, 6, 8, 10, and 12 hours under different load conditions (50g, 75g, 100g), the influence of friction on surface roughness is discussed. The experimental results show that, when the ratio between main agent and curing agent is higher, the SU8 surface roughness value is higher after the friction, as shown in Figure 7.

In addition, with the increased load, the SU8 surface roughness value has the ability to become higher, as shown in Figure 8.

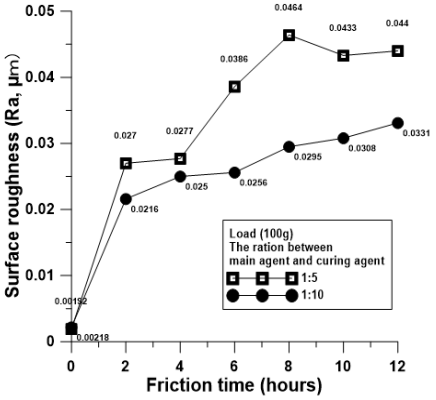


Figure 7.Influence of different composite proportion on SU8 surface roughness afterfriction

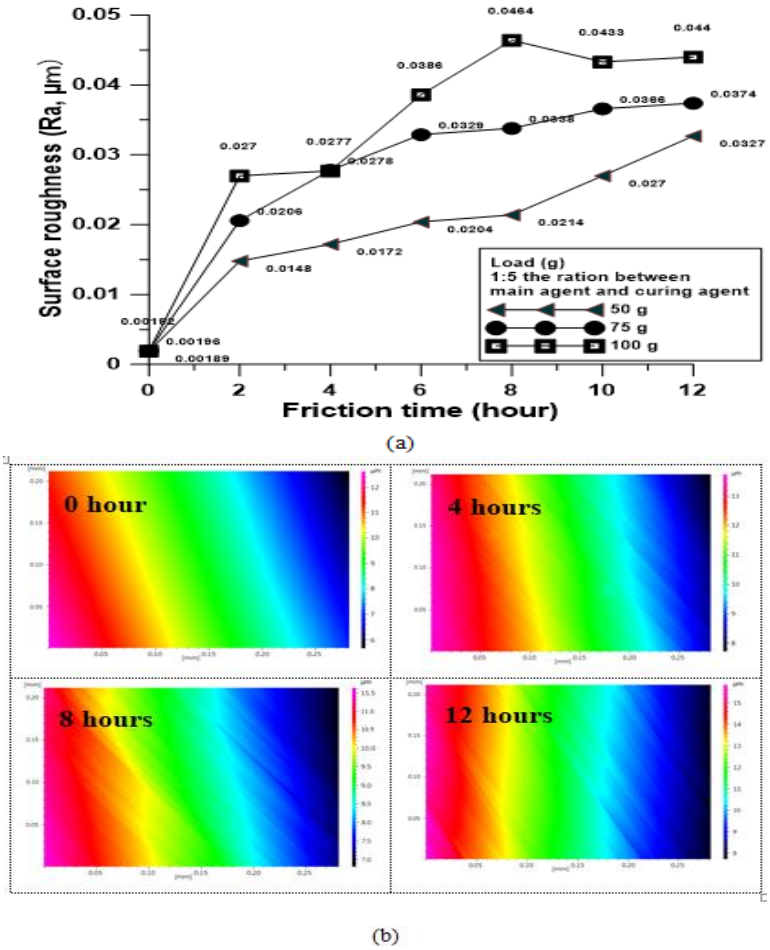


Figure 8.Influence of (a) different load on SU8 surface roughness after friction (b)surface topography (load 50g)

D. Influence of PDMS Soft Mold on SU8 Friction Test Experiment under Different Environment Temperatures

This section conducts experiment of PDMS soft mold (1:10) on SU8 friction under different environment temperatures (30°C, 40 °C, 50 °C, 60 °C), where one square temperature control environment is set (Figure 9), the friction system is established, and the influence of friction on surface roughness is explored under different load conditions (50g, 100g) by the friction test of Pin on Disk during 2, 4, 6, 8, 10, and 12 hours. The experimental results show that, surface roughness after friction testing will decrease with the increased load and environment temperature; in addition, the surface roughness under high load is still higher than that of a low load, as shown in Figure 10.

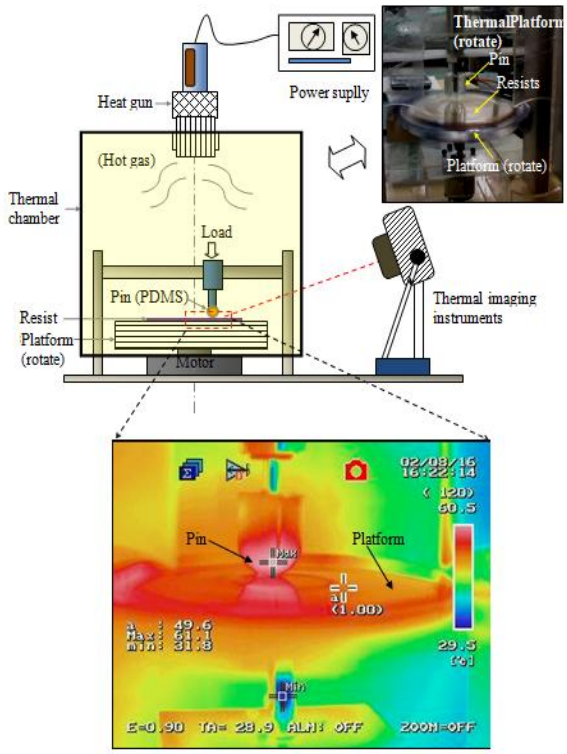
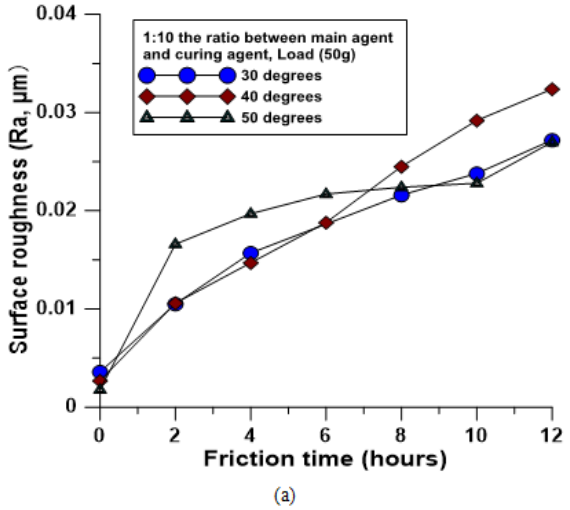
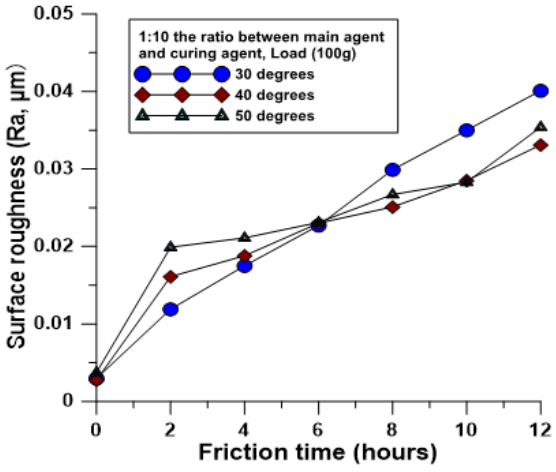


Figure 9.Temperature control system



(a)



(b)

Figure 10.1:5 ratio between main agent and curing agent (a) influence of differentenvironment temperatures on SU8 surface roughness after friction(b)influence of different time on white light scanning

E. Test and Simulation of Deformation of Contact Area of Friction Ball Head (Pin) End and Stress Distribution Status Under Different Conditions

This section conducts experiments using the performance of a friction ball head under different loads, as well as the actual contact area under different composite proportions, for analysis. The experimental results show that the contact area of the friction ball head end will increase with the increased load under different loads, as shown in Table 1.

Table 1.Influence of different loads on the contact area of friction ball head end

The ratio between main agent and curing agent	Load (g)		
	50	75	100
1:5	7.58 mm²	13.33 mm²	17.5 mm²
1:10	12.82 mm²	16.62 mm²	20.11 mm²

CONCLUSIONS

This research aimed to test the mechanical property of solid state SU8 under different conditions Polydimethylsiloxane (PDMS) soft mold, where one Pin on Disk friction tester is designed first in the experimental process, different conditions of PDMS soft mold to SU8friction test is explored, and mechanical property tests of PDMS soft mold material with different composite proportion and corresponding friction coefficient are analyzed. Finally, experiments are conducted to simulate the deformation of a friction ball head (Pin) contact point and stress distribution. Tests confirm that the high composite proportion of PDMS soft mold material will influence and increase surface roughness with increased pressure load. Moreover, the corresponding SU8 maximum static friction coefficient of a PDMS soft mold with a low composite ratio will also increase; while the deformation of a friction ball head (Pin)

contact point and stress distribution simulated under different conditions will be the same as the experimental results.

ACKNOWLEDGMENT

This work was partially supported by the Ministry of Science and Technology (Series No.MOST 107-2221-E-415 -003 -MY2, MOST 105-2221-E-415-005, MOST 104-2221-E-415-001) of Taiwan, Republic of China.

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