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Original research article

A piezoelectric jetting dispenser with a pin joint

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ABSTRACT

In order to improve the performance of the piezoelectric micro jetting dispenser used in opto-electronic packaging industry, a new structure of the needle with a pin joint is suggested. Dynamic characteristics of the proposed micro jetting dispenser has been improved because the needle can swing around the joint and motion interference between the needle and the guiding part is decreased with the new structure. Compared with the original dispenser, the needle stroke of the proposed dispenser is increased 1.8 times, and the velocity of the needle increased 1.4 times. The jet performance is also improved. Adhesives with viscosity of 1.8 Pa s are jetted by the new micro dispenser smoothly. The mathematical models and dynamics simulation model are established. The tested results agree with the simulation ones, which proves that the models and the structure of the proposed dispenser are reliable.

1. Introduction

With the development of opto-electronic packaging industry, jet dispensing technology has been developed rapidly in recent years [1–4]. The trends of consumer electronics are high integration and low price, which requires high efficiency and high consistency of jetting dispensers. Piezoelectric actuators are famous for high frequency and high precision [5–8]. They are competent for driving high speed jetting dispensers.

Some outstanding experts devote themselves to the research of piezoelectric jetting dispenser and get great achievements [9–13]. As the displacement output of piezoelectric ceramic is not large enough, a mechanical amplify mechanism is usually used to improve dynamic characteristics of the jetting dispenser. Wang L designed a piezoelectric jetting dispenser with a triangle mechanical amplifier [14,15]. Zhou has proposed several jetting dispensers with a lever mechanical amplifiers [16–18], and the rhombus magnifying mechanism is proposed to tackle motion interference between the needle and the guiding part [19]. Jeon presented a jetting dispenser whose needle is connected with the lever mechanical [20].Cheng proposed a kind of flexible amplification mechanism used in the jetting dispenser whose frequency can reach 300 Hz [21]. The previous lever mechanical amplifying method may induce motion interference between the needle and the guiding part. The work principle diagram of the previous mechanical amplifier is presented in Fig. 1(a). The needle is fixed on the end of the mechanical amplifier. And, the piezoelectric stack (treated as a spring) actuates the lever to swing. If the horizontal displacement of the needle exceeds the gap between the needle and the guiding part, motion interference occurs.

To decrease the motion interference and improve dynamic characteristics of jetting dispensers, a new structure of jetting dispenser with a pin joint is tested in this research. The principle of the new dispenser is shown in Fig. 1(b). The needle is divided into

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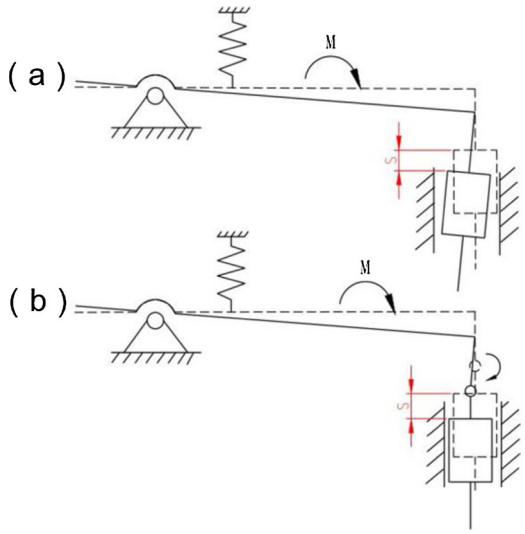

Fig. 1. Schematic diagram of mechanism. (a) is the previous structure. (b) is the new structure with a pin joint.

two parts, and they are connected by a slithery pin. The needle can rotate with the joint easily when the piezoelectric stack actuates the lever to swing. Motion interference is decreased through shortening rotation radius. With longer displacement, the needle will get higher speed under the same driving force. Then the increased energy will be transmitted to the adhesives. With more energy, it will be easier for the adhesives to overcome the higher surface tension and finish the breakup process of droplets. The needle stroke and velocity of the new jetting dispenser are increased 1.8 times and 2.5 times respectively.

Besides, a simulation model is established with Solidworks and Matlab to analysis the dynamic characteristics of the dispenser. This method is usually used in robot control field [22–25]. Compared with the traditional Simulink dynamics modeling and simulation [26,27], this method does not need to establish complex transfer function, and it has advantages of convenient and rapid modeling, and real-time monitoring of simulation results. A series of experiments are carried out. The results prove the simulation method is reliable. It provides a new method for improving the design and optimizing the performance of the dispenser. The influence of different high voltages and stiffness of the amplification mechanism on the performance of the needle is studied with the simulation and experimental platforms.

2. Experimental system

2.1. New structure and Principle of the dispenser

The structure of the original jetting dispenser is shown in Fig. 2(a), and the structure of the new dispenser is shown in Fig. 2(b). The needle is fixed on the end of the amplification mechanism in the original dispenser.

When the dispenser works, the interference between the needle and the guide part will influence the motion of the needle. With the new structure, the interference will be decreased drastically.

The square wave is used to drive the piezoelectric. When a high voltage is applied to the piezoelectric stack, the piezoelectric stack (PZT) extends [28,29] and makes the lever of the amplification mechanism rotating around the hinge center. The connecting rod rotates with the lever and the needle moves downward vertically. When the needle moves down, some adhesives close to the needle in the chamber flow downward because of the effect of viscous. And the pressure at the nozzle exit gradually increases until adhesives are jetted out. When the needle strikes on the nozzle, adhesives are cut off. Most adhesives jetted out from the nozzle will form a droplet, and the rest recoil to the nozzle. Then, power is off, and the piezoelectric stack restores to the original state. The needle returns to the balance position with the impact of hinge stiffness of the amplification mechanism. Then the cavity is filled with adhesives for the next cycle.

When the needle moves down and up, there is a small relative rotation between the needle and the connecting rod around the pin. The rotation can decrease the motion interference caused by horizontal displacement, so the dynamic characteristics of the needle and the jetting performance of the new dispenser is improved.

2.2. Experiment system

The experimental platform is shown in Fig. 3. In this study, a TEC AFG3102 signal generator is used to generate control signal. The signal is amplified by PI E-617 power amplifier to drive a piezoelectric stack. The model of the piezoelectric stack is PI P-887.91. A precise pressure regulating valve is used to control filling pressure. A laser displacement sensor is used to measure and record the real-time displacement of the needle. The sampling period is 100us, which can meet the measurement needs of the needle at a