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Multi-objective optimization on laser solder jet bonding process in head gimbal assembly using the response surface methodology

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ABSTRACT

This paper aims to investigate the effect of laser solder jet bonding parameters to the solder joints in Head Gimbal Assembly. Laser solder jet bonding utilizes the fiber laser to melt solder ball in capillary. The molten solder is transferred to two bonding pads by nitrogen gas. The response surface methodology have been used to investigate the effects of laser energy, wait time, nitrogen gas pressure, and focal position on the shear strength of solder joints and the change of pitch static attitude (PSA). The response surface methodology is employed to establish the reliable mathematical relationships between the laser soldering parameters and desired responses. Then, multi-objective optimization is conducted to determine the optimal process parameters that can enhance the joint shear strength and minimize the change of PSA. The validation test confirms that the predicted value has good agreement with the actual value.

1. Introduction

Laser soldering is a technique used to melt and solder the electrical connection joints. Lead-free soldering is renowned with complete success in a wide range of electronic assembly industrial applications. Though, there are several great concerns due to the increasing demand and popularity of portable electronic products such as a mobile hard disk and laptop computers. Laser solder jet bonding (SJB) which is a process for joining the electrical circuits of head gimbal assembly (HGA) has a big effects on solder joint reliability and pitch static attitude (PSA) of HGA in hard disk drive (HDD). Typically, lead-free wave soldering is well known to achieve reliable solder joints as it is done on a large scale. However, magnetic disks require laser solder jet bonding due to small dimension of physical joint. The quality of the solder joint directly improves recording density and reliability of an HDD. Fluxless SnAgCu (SAC) solder in the form of solder ball is used in laser SJB process. Laser is the energy source for reflowing the solder ball.

The reviews on the solder joints, the laser soldering process, the optimization of process parameters, and the laser applications will be provided as follows. Typically, the solder is pasted on the surface of the printed circuit board (PCB) or flexible printed circuit board (FPCB). Then, heat is needed to melt the solder before performing the solder joints. Infrared heater is commonly used as the heat source in reflow oven. A literature on the mechanical properties of solder joints in the component assembly on flexible printed circuit board (FPCB) was proposed by [1]. Reflow process, mechanical shear test and metallurgical analysis of solder joint were reported in their work. The study of properties and microstructures of SnAgCu-xEu as the solder joint for concentrator silicon solar cells was provided by Zhang et al. [2]. The results indicated that the addition of the Eu can improve the solder mechanical properties in terms of tensile strength, shear strength, creep resistance and thermal fatigue reliability. Microstructure and mechanical properties of Sn-Ag-Cu alloys were discussed in [3,4]. In addition, near eutectic SnAg and SnAgCu solder ball with various solder bump heights were adopted to characterize the microstructure in solder alloys [5].

Papers on the laser soldering process were discussed by [6–14]. A comparison on the strength of solder joints obtained from laser reflow and infrared reflow was provided by [6]. It was found that laser input energy and heating time mainly contributed to Au-Sn intermetallic compound morphology. Kods et al. [7] studied the laser soldering on flip-chip package. The laser powers, heating rates and illumination times were examined to obtain the good quality of solder in terms of preliminary thermal, electrical and mechanical properties. Experiments on soldering process with Sn-3.5Ag-0.5Cu (SAC305) lead-free solder on Au/Ni/Cu pad were

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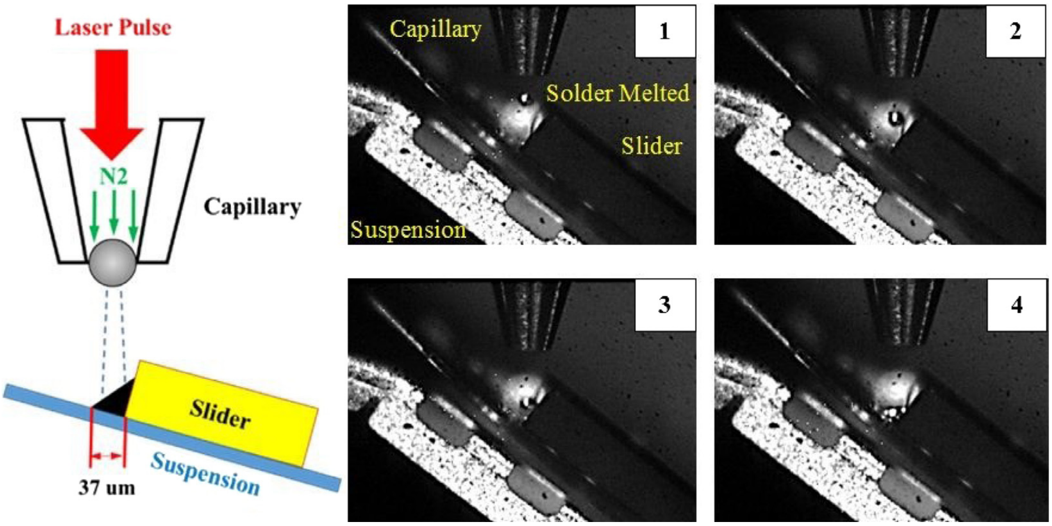

Fig. 1. Laser solder jet bonding process for HGA.

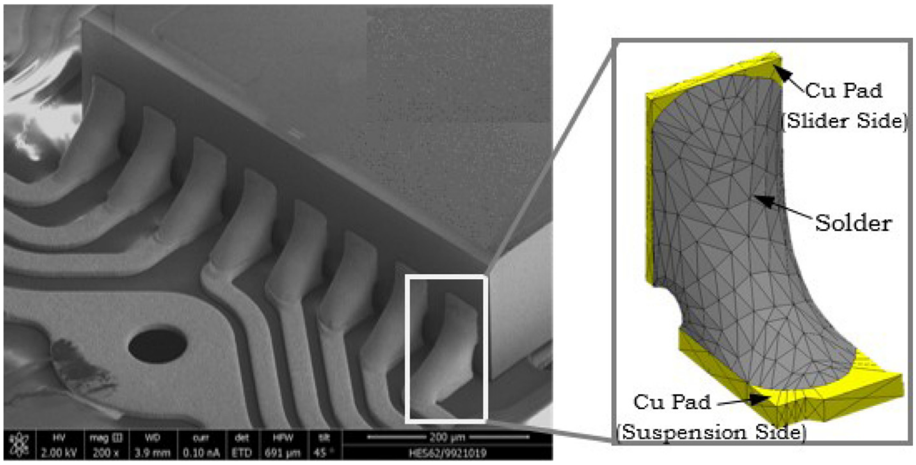

Fig. 2. Solder joints between slider pads and suspension pads.

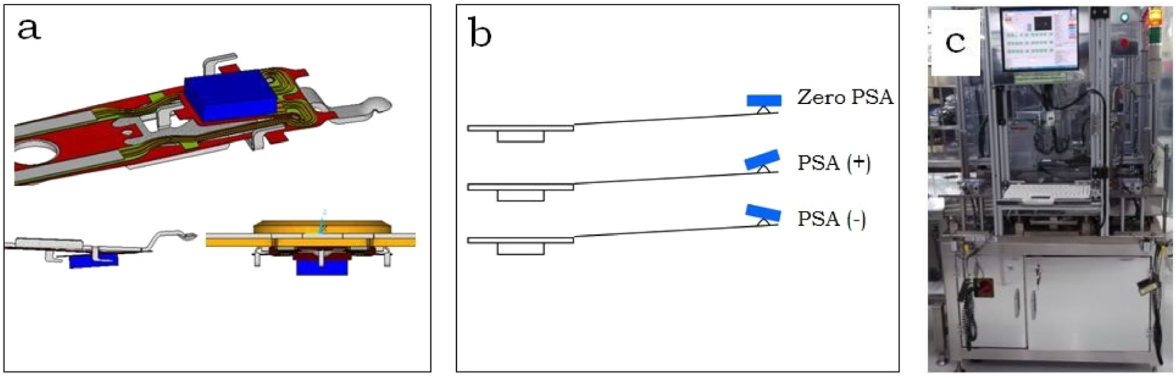

Fig. 3. (a) Pitch static attitude on slider. (b) Possible values of pitch static attitude. (c) Measurement machine for pitch static attitude.

presented by [8]. The result revealed that laser power enhance high shear force which was 70% higher than using IR reflow method. The paper on the effects soft beam heat profile on the microstructure of Pb37Sn, Au20Sn and SAC305 solder joints using laser diode was done by Tan et al. [9]. It was found that SAC305 showed the good response to the laser soft beam. [10–13] studied the effects of laser parameters on mechanical properties and microstructures of solder joints in the assembly of components. The common laser parameters of laser soldering examined in the experiments were laser power and laser time [6–12]. These literatures reveal that laser power and time had significant effects to the mechanical properties such as tensile strength, shear strength, etc. The