Synchronization System of Galvanometer Scanner and 2-axis Linear Stage for Laser Routing in Wide Area FPCB Coverlay

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ABSTRACT
In this current research, the two-axis galvanometer laser scanner and the two-axis linear stage system are synchronized for wide area laser machining with high machining speed. This synchronization system is used as the laser routing machine at consistent machining speed, 170mm/s with a 350×350 mm² area, which area is much larger than the galvanometer scanner working field. The coverlay of FPCB (Flexible PCB) is routed and accuracy is measured as about 5µm, which is similar error regime of a galvanometer scanner itself.

INTRODUCTION
Recently, laser machining is being employed increasingly in many diverse micro fabrication areas such as biomedicine, automotive manufacture, display devices, and semiconductors [1]. A galvanometer scanner delivers laser beam at certain position by rotating two mirrors using galvanometer motors with high speed. However, it has limitation of working area maintaining same optical accuracy. If a focal length which is distance from a f-theta lens to a sample is longer, working area may be larger but optical accuracy becomes worse. A linear stage system can guarantee high positional accuracy with wide area but it has limitation of fabrication speed. To combine two individual systems, step-and-scanning method is popularly applied. During a galvanometer scanner fabricating a sample, a linear stage system stops. After fining fabrication of certain working area of a galvanometer scanner, a linear stage moves next step and a galvanometer scanner fabricates again. This method always meets discontinuities problems at intersection of scanning area and obviously slow machining speed [2].

To overcome this problem, we dynamically combine and synchronize two systems. By this method, we routes continuously without any stopping motion and routing area is extended to two-axis linear stages area without drawback of machining speed.

METHODOLOGY
The synchronization system is built with the 3-axis linear stage, the 2-axis galvanometer scanner, the 355nm ns second laser source, vision system, and controllers which includes the motion controller, the scanner control board as shown Fig.1. Position and speed of the linear stage is fed to the scanner control board by the 2-axis encoder signals. In the scanner control board, scanner movement is calculated by comparison original CAD data and stage movement. The micro vectors of the galvanometer scanner with 10µs intervals always compensate micro motion of the linear stages. In general, stage motion is slower than scanner motion due to its heavy weigh.

![FIGURE 1. Schematic sketch & experimental built up of the laser synchronization system.](image-url)
RESULTS AND DISCUSSION

Before operating the laser routing machine, macro motion of the linear stage and micro motion of the galvanometer scanner is separated. As shown in Fig.2, FBCB (Flexible PCB) coverlay of the smart phone camera module is planned to be routed. Size of coverlay sheet is 350×350 mm$^2$, which is much larger than working area of the galvanometer scanner, 50×50 mm$^2$. The stage motion is selected to be covered whole coverlay sheet and maximum speed and acceleration capability is considered. Due to the low inertia of the linear stage, motion and speed change should be minimized. Even though working area of the galvanometer scanner is narrow, the galvanometer scanner has high inertia which is over 10g in general. Path of it is then suitable for high frequency motion and quick change of speed. Most important thing for path separation, summation of the linear stage speed and the galvanometer scanner speed is constant to maintain constant routing speed. High routing speed can cause poor cutting edge or low routing speed can make cutting edge burn.

FIGURE 2. Routing path of synchronization system and photo of routed coverlay sample.

In Fig. 3, some routed FPCB coverlay samples are selected and measured side length and diameter. Most of samples are within 5 $\mu$m error range. Maximum error is measured as 5.61 $\mu$m in sample 3. When the sample is routed with only the galvanometer scanner, the error regime is measured in similar range.

FIGURE 3. Photo of some routed samples and measurement data

CONCLUSION

The two-axis galvanometer laser scanner and the two-axis linear stage system were synchronized for wide area laser machining with high speed. Macro motion of the stage movement was planned with its maximum speed and inertia. In other hands, motion of the galvanometer scanner was planned with a high frequency in small working area. The synchronized laser machine was applied to route the FPCB coverlay sample with a 170mm/s speed. The accuracy was measured in about 5 $\mu$m, which was similar error regime of a galvanometer scanner itself.

REFERENCES
