

## Development of a Real-Time Auto Focus Microscope System for Micro-Stereolithography

Yijie Liu<sup>1,2</sup>, Zhen Zhang<sup>1,2</sup>

<sup>1</sup>State Key Laboratory of Tribology & Institute of Manufacturing Engineering, Department of Mechanical Engineering, Tsinghua University, Beijing 100084, China

<sup>2</sup>Beijing Key Laboratory of Precision/Ultra-precision Manufacturing Equipments and Control, Tsinghua University, Beijing 100084, China

zzhang@tsinghua.edu.cn

### Abstract

Auto focus systems are widely used in many scientific and industrial applications, such as microscopic imaging, laser direct writing, stereolithography. For the application of micro-stereolithography (MSL), there is a need to keep the surface of the sample within the focal depth of several microns. To tackle the challenge, in this paper, we propose a real-time image based auto focus microscope system. The important feature of the proposed system lies in the focused spot size is of the micron-level by appropriate optical design and image processing algorithms. For the optical design, a transmissive beam splitter is utilized, by which the laser beam can pass to fabricate, and the focused beam on the lithographic surface is reflected to the microscope head and camera. The proposed image processing algorithm is based on a minimum enclosing circle and brightness to effectively determine the focusing condition comparing to the conventional ones based on the clarity of images. In the minimum enclosing circle algorithm, the spot is enclosed in a minimum enclosing circle to determine the position and size of the laser spot. And in the brightness algorithm, the brightness and energy are increased after laser focusing, and the focus point is determined by calculating the number of pixels exceeding the brightness threshold. Compared with the traditional method of auto focus microscope systems, the proposed system is advantageous of high accuracy and fast focus speed for the requirement of MSL process. The auto focus system uses a camera to display the laser spot on the lithographic plane in real time, and then processes the images to drive the motor along Z axis to achieve auto focusing. For the next laser spot image, the above cycle is repeated until the laser focus position is found. The experimental results show that the proposed auto focus system is able to deal with the laser spot images in real time, and to effectively determine the focus status, as well as to realize auto focus through visual servo control.

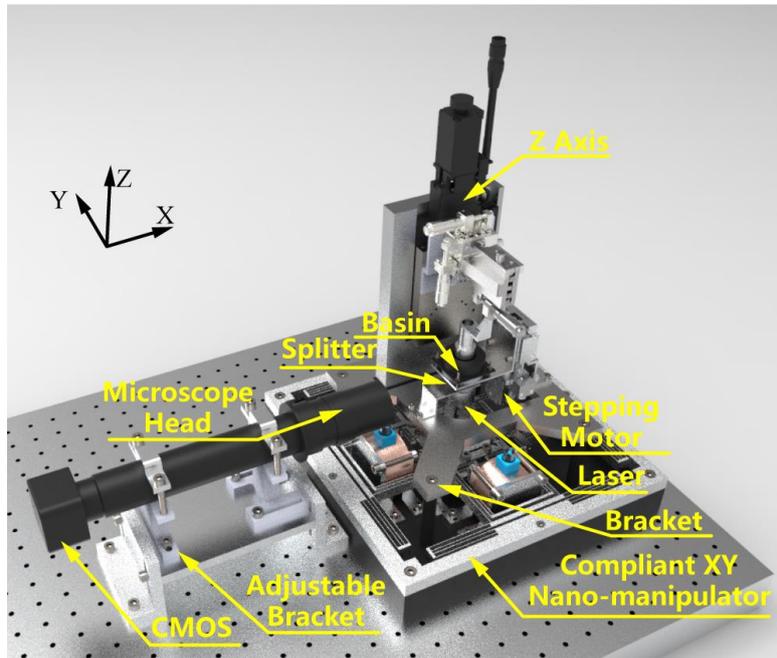


Figure 1: Schematic of the auto focus system based MSL apparatus