Blu-ray laser system for light exposure of photoresists on three dimensional surfaces

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Abstract

For the microstructuring of thin films by photolithographic means, a laser system for light exposure, utilising a highly precise four axis kinematics was developed. The system is part of PTBs modular microfabrication facilities and, therefore, a further stage of development of the units presented in the past [2-4].

The structures obtainable have a minimum width of a few ten micrometre, e.g. for the primarily intended use as a directly sputtered thin-film sensor. The wavelength of the laser system has to meet the requirements of the photoresist. Therefore, a low priced blu-ray laser diode (wavelength: 405 nm) was installed.

For the intended application, a great variety of workpieces need to be handled.

1 Introduction

Today’s requirements in precise measurement, especially for a national metrology institute as PTB, provide a special demand in the development of novel sensor technologies. Thin-film sensors, which are applied by magnetron sputtering directly to the component under test, are such a technology [1].

To achieve a suitable conductive thin-film microstructure, distinct photolithographic steps are conducted. One of them is the selective light exposure of the photoresist (see fig.1, left) which is, in this case, not applied to a standard Si-wafer as generally used in microelectronics, but on a three dimensional surface of an arbitrary workpiece, instead. Nevertheless, a minimum lateral structure size of a few ten micrometres has to be achieved.

The sytem presented in this paper fulfils these requirements. Building upon systems set up earlier, a kinematic and optical setup has been developed. A minimum of single components and an easy adjustment of the system are the foundation for a fast change between the different micro-fabrication capabilities.

Hence, it is now possible to turn [2], to lap/polish [3], to assemble [4], and to structure surfaces in the micrometre range on different systems,all sharing the same footprint.

2 Requirements

The system should not exceed a footprint of 400 x 600 mm², so that it does fit into a laminar flow bench. At the same time, the lateral work space needs a size of 100 x 100 x 50 mm³ at the least, to be able to structure films on a huge variety of components of different sizes and geometries.

For the intended use of the system, an exposure of the whole lateral area of the workpiece is required. Additionally, the focal point of the laser has to be adjustable. The resulting complex motions are realised using three linear and one rotational axis.The workpiece is connected to the rotatory axis.

The correct position of the workpiece, especially its surface and, with it, the starting point of light exposure, has to be identified in the x-, y- and z-axis optically and with high precision. The positioning accuracy required is at least 1 µm, which requires high quality cameras and especially lenses with magnification and very good image performance.

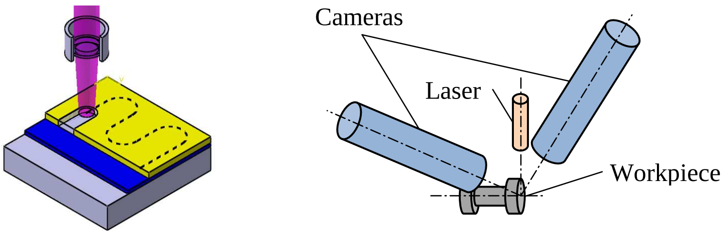

Figure 1: Selective light exposure by a laser beam (left) and configuration of laser and cameras to focus one single spot on the surface of the workpiece (right)

3 Kinematic Setup

Based on the requirements stated above, the following kinematic setup has been developed. To reduce deviations, but still have a maximum of working space, two linear axes permitting a travel of 100 mm, are mounted perpendicular and directly to the base plate. A linear axis with a travel of 50 mm will serve as z-axis.

The two cameras and the laser are mounted in one plane, so that only one single focal point is achieved (fig.1 right). The optical angles of the cameras are perpendicular to each other, the laser-axis divides the angle in halves. Z-axis motion is used to focus the laser-camera-unit onto the surface.

A rotational axis is mounted perpendicular to the x-y-plane, in that way, processing of the whole outer shell of the WP is possible. Fixed to this axis is the mounting which comprises a screw thread with a precisely machined dead stop and is therefore highly adaptable. The full kinematic setup is depicted in figure 2.

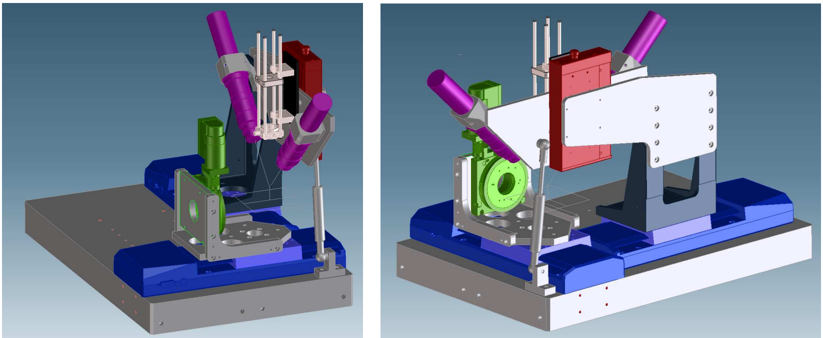

Figure 2: 3D-CAD-Model of the light exposure system

4 Laser System

The laser system is equipped with a low-cost blu-ray laser diode with a wavelength of 405 nm and, therefore, very suitable for the light exposure of common photo resists.

Blu-ray laser diodes often have a rather high output power (in this case a 100 mW diode is used), but suffer from a divergent beam. Consequently, an optical setup assures that the light is coupled into an optical fibre of ten micrometer. The end of the fibre is mounted to the camera unit and the light finally passes through a biconvex lens to acquire a high quality focal point at a working distance of 100 mm. Besides, the mass of the latter system is much less, which is favourable for stability and precision of the kinematic chain.

5 Software

The software for continuous path control will be capable to parse standard NC G-Code to transform it into the machine's coordinate system. With it, a continuous workflow (CAD design of the microstructure, conversion to CAM data, and transformation to the exposure system and finally the light exposure itself) is guaranteed.

6 Summary

A system for the light exposure of photoresists as a part of PTB's micro-fabrication facilities has been presented. It is equipped with a highly precise 4-axis kinematics which can support parts with diverse geometry. The exposure is realised by a blu-ray laser diode and an optical system to achieve a laser spot of a few ten micrometer which can be positioned and controlled by two cameras.

As of this writing, a makeshift setup is operational, the parts needed for a permanent setup are being manufactured and will be put into service in the next month.

7 Acknowledgements

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