BIOMEMS PHOTOMASK ALIGNER

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Motivation

The design project client and his students are having difficulty correctly aligning multiple photomasks, which inspired the client to propose a photomask alignment device. In practice, this device would be able to accurately align masks within a range of 10 to 100 µm. Currently, manual alignment is done under a microscope and is accurate within range of 200 to 300 µm. This difference in tolerance can cause misalignment of the mask patterns created by photolithography, causing the client to have to restart the process. Therefore, an accurate alignment device would minimize material waste and reduce manufacturing time.

Introduction

Background:

- BioMEMS is short for "Biological Micro-Electro-Mechanical Systems." It is an interdisciplinary field that combines principles from biology, microfabrication, and electronics to develop devices and systems for biological and medical applications.
- A process called photolithography involves shining UV light onto photocurable epoxy, often used when creating photo resistant layers.
- Photomasks are printed in various shapes and sizes using a laser or e-beam writer.
- The EVG®610 Mask Alignment System is a machine that provides an accuracy of around 0.5 µm, however, a used EVG aligner can cost $40,000 or more.
- Accurate alignment of the photomasks onto silicon wafers is imperative, as seamless overlap of patterns on the masks is essential to guarantee the optimal functionality of the end product.

Design Specifications:

- Alignment accuracy in the range of 10-100 µm
- Wafer holder must secure a 3” wafer
- Final product costs less than $100
- Hole punch for photomasks must be accurate
- Resistant to UV light

Final Design

- Our final design consists of an ASA base with a section cut out of it. A second piece, the holder itself, will then get the silicon wafer aligned on the base.
- The holder is 0.025 in shorter than the base cutout, and creates a lip that the wafer is braced against to remain in place.
- A third piece, a block stopper, hits the flat edge of the wafer to finally secure it in place and align it correctly.
- Alignment pillars then stick out of the base to allow an accurate alignment of masks onto the wafer.
- Then photolithography transfers a pattern from a mask into the resist. This is then used for subsequent pattern transfer onto a working surface.

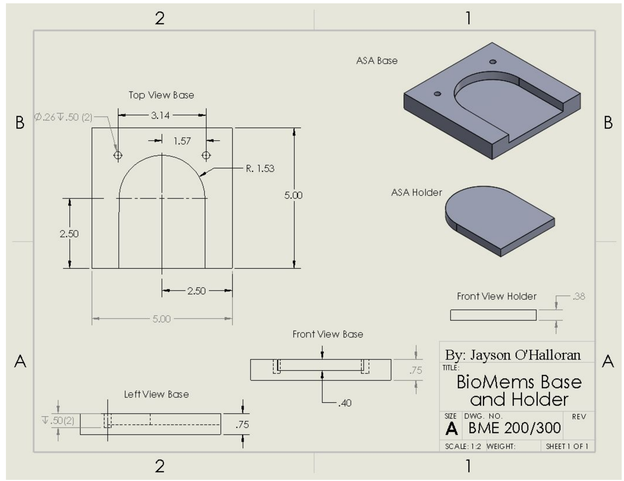


Figure 1: BioMEMS Base and Holder

Fabrication

- The base and holder were fabricated using solidworks.
- The base and holder were 3D printed using a Bambu Labs X1C 3D printer in the Makerspace.
- The alignment pillars (x2) were sourced from the BME storage room and were each ¼ inches in diameter. They were filed with sandpaper to better fit into the base.
- The hole-punching stamp was bought from a third party source on Amazon.
- The hole-punching alignment cross was cut from wood using hand tools.

Future Work & Discussion

- Change the infill thickness of the base and holder to 80%. Further reduce the size of the base & holder.
- Create a hole punch mechanism similar to a stamp.
- Create an adjustable model that can accommodate four and six inch wafer sizes. (DIY Instructions)
- Create a cut out flat lip for the base that fits to the top-flat of the wafer.

Testing and Results

Accuracy Testing:

- Tested hole punch accuracy by aligning the target circles on the photomask and then measured accuracy of the holes.
- Tested mask alignment error by measuring overlap of the photomask over the wafer under a microscope using the BioMEMS photomask aligner.

Error:

- Human error was accounted for in the photomask alignment by measuring the misalignment of the target circles under a microscope.
- 3D printing was unable to create an exact base and holder that had the tolerance needed. 3D printing slightly warped the aligner and effected the accuracy of the device.

Error Points:

- 3D Printing
- Laser Cutting
- Rotation
- Human
- Hole Punching
- Alignment Rods

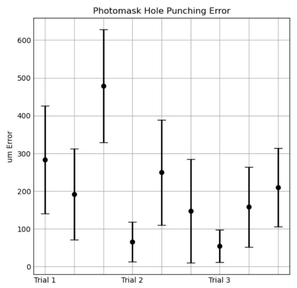


Figure 2: Error bar graph of hole punch

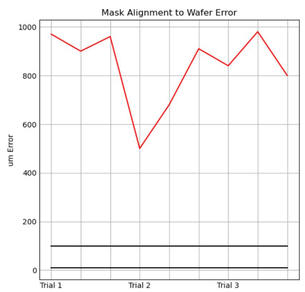
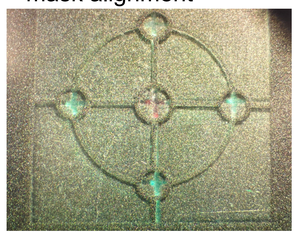


Figure 3: Error of mask to wafer alignment

Figure 4: Hole punch mask alignment



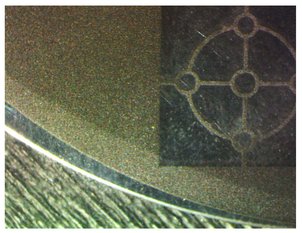


Figure 5: Mask & Wafer on photomask aligner

Acknowledgements & References

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- Thank you Dr. Brockman for continually supporting us throughout the design process.
- Thank you to the Makerspace staff for providing assistance during the fabrication process.

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[3] Mask alignment systems, https://www.evgroup.com/products/lithography/mask-alignment-systems (accessed Oct. 27, 2023).