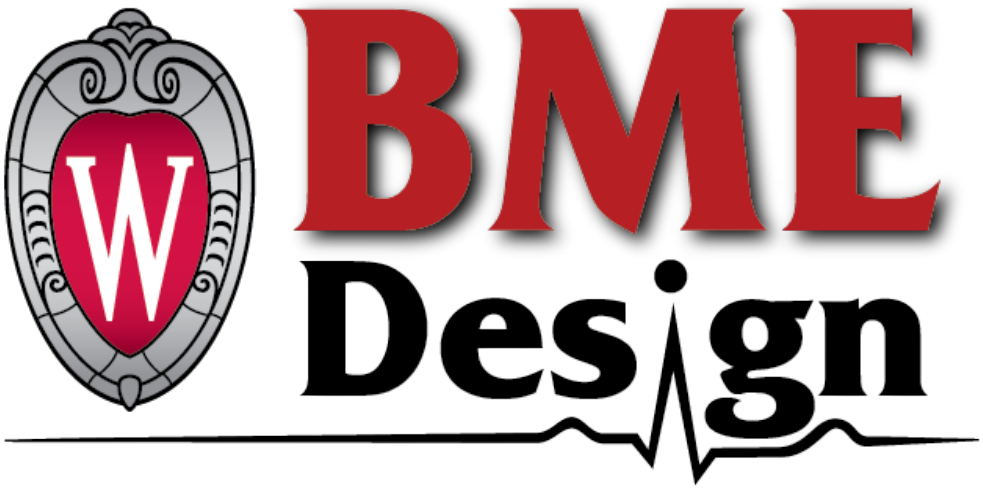


# Low-Cost BioMEMS Photomask Aligner

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Preliminary Product Design Specifications

*BME 200/300*

*Lab Section #: 303*

Team Members:

Jayson O'Halloran, Co-Team Leader

Emily Stoebe, Co-Team Leader

Luke Waldhuetter, Communicator

Saketh Peddireddy, BSAC

George Moran, BPAG

Paulie Reuteman, BWIG

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**Function :**
The low cost BioMEMS photomask aligner is a device that is meant to align photomasks relative to each other so that when used in photolithography applications, separately spun photoresist layers are properly aligned for a multitude of uses such as individual cell culture. The photomask aligner must be extremely accurate down to micro-measurements in order to complete this goal.

**Client requirements:**

- The photomask aligner must be accurate under 100 microns but preferably within 10 microns in accuracy
- The aligner should be able to be held 12 microns above the photoresist layers to ensure the pattern is burned into the photoresist accurately
- The aligner should be resistant to the baking step of the photolithography process

**Design requirements:**

1. Physical and Operational Characteristics

    a. *Performance requirement*s:

        The photomask aligner should be able to hold the base plate and the subsequent photoresist layers in such a way that the sequence of photomasks are all aligned within 100 microns of each other. Preferably, the photomasks will be aligned within 10 microns of each other, however, 100 microns is the stronger requirement. The aligner should also be able to hold the photomasks about 12 microns above the photoresist layers so that the patterns can be accurately burned into each photoresist layer. Finally, the entire device should be resistant to temperatures of 90-110C [1] to be resistant to the baking step of the photolithography process.

    b. *Safety*:

        The aligner is meant to be used in a teaching lab so it must be extremely safe to use. It must not melt under the aforementioned 90-110C to prevent potential damage to other items in the lab. It also must not conduct heat easily, to prevent burns to the users. It should be able to remain under 52C [2] at all times even during the baking step. Naturally, it should have limited sharp edges or pointy parts to ensure minimized cuts and other physical damage. The aligner should

also have a strong center of gravity and be under 2 pounds [3] to prevent potential harm due to falling or dropping.

c. *Accuracy and Reliability*:

The aligner should be accurate to 100 microns but preferably accurate down to 10 microns. The aligner should also be able to hold the photomasks about 12 microns above each layer. The aligner should be able to repeat the layer making process nearly exactly between all uses. This means that the aligner should be accurate down to 5 microns between runs. However, as long as the aligner works as intended for each individual run, it will serve its purpose.

d. *Life in Service*:

The photomask aligner must consistently maintain similar conditions throughout the duration of usage. Since the aligner has to layer masks over each other to a difference of 10 microns, the photomask aligner must be able to accurately layer masks 5 times to complete tests. The time it takes the photomask aligner to align two to three masks (at most four) will take approximately fifteen minutes. The fifteen minutes includes time it takes to align, bake, and run the UV light process.

e. *Shelf Life*:

It is estimated that the product should last more than ten years [4]. Since the photomask aligner will be made out of material similar to Plexiglass, it will be able to withstand temperatures as low as -40C and as high as 200C . However, room temperature storage is ideal.

f. *Operating Environment*:

The aligner is designed to operate within a teaching environment meaning it must be relatively easy to use. It also must be able to withstand 90-110C during the baking stage of the photolithography as stated previously. Sterilization is not a priority for this device and it will not require a clean room to operate. However, this device will likely be used under a fume hood due to the SU-8 solvent that will be applied to the wafers during the photolithography process [5].

g. *Ergonomics*:

The ergonomics of the photomask aligner must allow the photomasks to be placed into the aligner and adjusted relatively easily. It also is critical that the photomasks are able to be aligned extremely accurately. The aligner will have a feature that allows the user to swivel the mask out of the way to allow the user to

bake the wafers without them leaving the aligner. Another critical consideration is the ability of the aligner to maintain alignment throughout the photolithography process to ensure a properly aligned product.

h. *Size*:

The photomask aligner is designed to fit varying wafer diameters and thicknesses. The typical sizes are 3, 4, and 6 inches. The thickness of the wafers ranges but this does not affect the alignment of the photomasks. The size of the aligner is not a critical factor. The only requirement is that it will fit under a fume hood. It does not need to be moved.

i. *Weight*:

Acrylic is a lightweight material, which will be used for the aligner. No weight specification was provided, but an estimate of about under 2 pounds for the aligner is a good gauge of what it should be, as it needs to have a strong center of gravity and be able to prevent damage from falls or chips [3].

j. *Materials*:

Both acrylic and polycarbonate were in consideration for the photomask aligner. Both are lightweight materials that will be able to withstand the temperature range it needs to, while staying under 2 pounds as stated before. Acrylic is more likely to shatter while polycarbonate is more likely to get scratches [6]. Acrylic is also cheaper than polycarbonate, which is big considering the budget of $100. Ultimately, acrylic is the final decision, as scratches would not be good to have for a device that needs to be transparent, and acrylic is much cheaper [7].

k. *Aesthetics, Appearance, and Finish*:

The aesthetic and appearance of the photomask aligner, due to the acrylic material, will be a glossy, polished finish. The appearance will be a small device with three circles that are adjustable in height. It will most likely be the same color throughout and whatever color the client.

2. Production Characteristics

*a. Quantity:*

Only one alignment mechanism needs to be produced. This alignment mechanism will consist of one rod with three attached mask holders.

*b. Target Product Cost:*

The components needed to construct this mask aligner are the mask holders, the rod to which they are attached, and a means of attaching them. Acrylic is resistant to photolithography so acrylic mask holders, an acrylic rod, and acrylic glue will be used. The acrylic mask holders should cost about $5 [8] a piece, giving a total sum of $15. The acrylic rod will cost about $3.63 [9], and the acrylic glue will cost $10 [10]. None of these prices account for tax or shipping costs, so an additional $5 is added for confidence. Additionally, the acrylic rod and acrylic photomask holders will need to be modified, but that should come free of cost at one of the provided labs. Thus, the total cost to construct the photomask aligner should be around $35.

3. Miscellaneous

a. *Standards and Specifications*:

The photomask aligner is not classified by the FDA because it is not a device intended for clinical use or diagnostic purposes, rather it is used in research and laboratory settings. While there are no specific ASTM standards for this project, all individuals interested in using this device should have an understanding of photomask alignment prior to use of the aligner. This is due to the aligner being used for various techniques such as cell cultures, biochemical assays, mask mold alignment, etc.

b. *Customer*:

The customer is requesting the production of a Low-Cost BioMEMS Photomask Aligner that can provide accuracy between 10 and 100 μm during mask alignment, ideally closer to the 10 μm range. Currently the client creates photomasks in a CAD program, creating alignment marks on each mask [11]. The amount, location, and shape of the alignment marks varies based on preference. As expected with photomask alignment by hand and eye coordination, the resolution is to be around 200-300μm of accuracy at the very best, which is three to twenty times the scale than what is done with the traditional photomask aligner device.

c. *Patient-related concerns*:

Currently, there are no patent-related concerns when it comes to the usage of photomask aligners.

d. *Competition*:

There are existing means of aligning photomasks for comparable research and experimental practices. However, many are quite expensive; the cheapest manual mask aligner sells for under, but in the range of, $7,500 [12], and automated mask aligners sell for even more.

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