EXECUTIVE SUMMARY

Our project is to design a high accuracy alignment platform for Multilayer Soft Lithography that is easy to use. The following page discusses the contents of our report including the design problem, customer requirements, engineering specifications, project plan, concepts generated, concept selection methodology, the final chosen concept, the prototype design, manufacturing plan, and validation results.

Multilayer Soft Lithography (MSL) is a microfabrication technique that constructs 3D structures by bonding layers of elastomers such as polydimethylsiloxane (PDMS). Each layer is first individually cast on a micromachined mold or engraved pattern before being aligned and, subsequently, bonded. Our sponsor has tasked us to develop a PDMS to PDMS alignment system that was more accurate and less tedious than their current platform.

We first collected user feedback to form our design requirements. These user requirements were substantiated with findings from our literature review, patent search, and benchmarks from relevant commercially available products. The requirements were then converted into quantifiable engineering specifications and ranked in importance, shown in Table 1.

Next, we resolved the primary function of our device, which is to align two PDMS layers, into its constituent parts that are represented via a Functional Decomposition chart. We then targeted each sub-function individually and developed several modules to address them. We employed a Go/No Go strategy and a Pugh chart to filter down the ideas and select the one that best met our specifications. We conducted a thorough analysis of our design concept to finalize our parameters and dimensions.

Every component of our final prototype has higher accuracy and tolerances than the current crude platform. By keeping the basic inputs the same and removing all the redundant ones, we've ensured that even a novice user will be able to align two layers quickly and accurately. Our device consists of two digital microscopes, three high resolution stages, and two focus racks that were purchased. All other parts, including the baseplate, top and bottom frame and holder were manufactured out of aluminum.

Overall we met nearly all the specifications laid out by our sponsor. The only criteria we were unable to meet was the budget, which we slightly exceeded. Our design performs much better than the current benchmark device and all the stakeholders were satisfied with the result. However, our sponsor suggested additional features and improvements, which we will continue working on outside of the scope of the class.

Table 1: Engineering specifications and validation results

Requirements	Engineering Specifications	Validation Results
Accuracy	20-50 microns	33.6 ± 20.5 microns
Pre-activation alignment time	< 10 minutes	4.1 ± 1.0 minutes
Post-activation alignment time	< 5 minutes	4.0 ± 1.9 minutes
# of inputs	<14	12
Height adjustability	> 7 cm	8 cm
Alignment stage size	> 2" x 3"	4.5" x 5.1"
Repeatability of top stage	< 500 microns	12.7 ± 5.4 microns
Repeatability of bottom stage	< 500 microns	9.0 ± 3.4 microns
Stability better than benchmark	< 41.9 ± 61.6	24.9 ± 24.4
Portability – Weight	< 40 lbs	20 lbs
Portability – Size	< 14" x 14"	8" x 10"
Cost	<$2000	$2019.18