Direct Write Maskless Lithography for Integrating Microfluidics and Electronics

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Current PCB manufacturing provides critical dimensions on the order of 100µm. While this is sufficient for electronics, it is not suitable for biochips which integrate microfluidics and electronics (mostly bare dies). Bare die - PCB integration is currently performed using direct chip-on-board technology which uses wirebonding, making integrating other features like fluidics cumbersome.

Conventional semiconductor optical lithography equipment, such as contact aligners, can achieve resolution on the order of 1-2 microns for critical dimensions. A diagram illustrating how such a system works is shown in FIG. 1.

As shown, a layer of UV-sensitive (positive) photoresist is deposited on a substrate, and a mask with openings is placed above the substrate. UV light is illuminated over the mask, and the portion of light incident on the openings passes through the openings and is absorbed by the photoresist. The light causes the illuminated portions of the PR layer to become more soluble in a base developer than the non-illuminated portions. The substrate is then soaked in a developer, which dissolves the illuminated PR, leaving a PR mask on the wafer which can then be used, for example, to selectively deposit metal or other thin films in the openings, or as an etch mask in order to selectively etch the substrate below the openings.

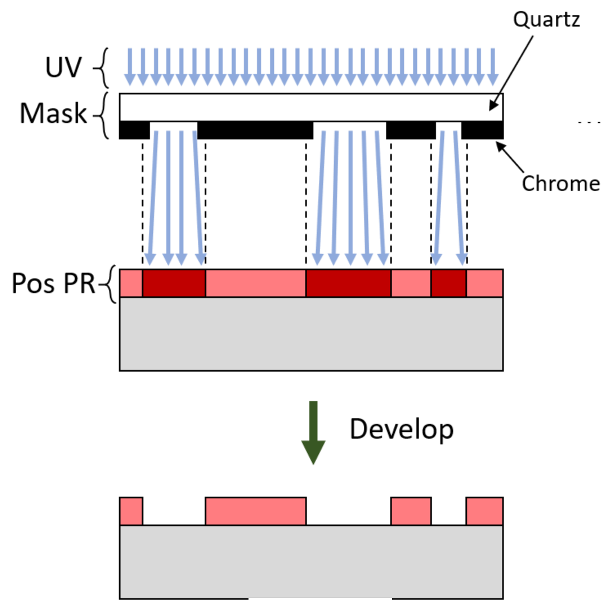

FIG. 1

While a contact aligner can achieve sufficiently small features for many applications, it is an expensive tool, and further requires that a physical mask plate be designed and fabricated each time a user wishes to expose a new pattern.

The goal of this project is to design and build a lithography system in which the light source and physical mask is replaced by a projector that can project a UV light pattern onto the wafer. The user should be able to place a PR-coated wafer below the projector, upload an image file into the projector, and then have the projector illuminate the sample with the image for a predetermined amount of time. A sample system is shown below in FIG. 2.

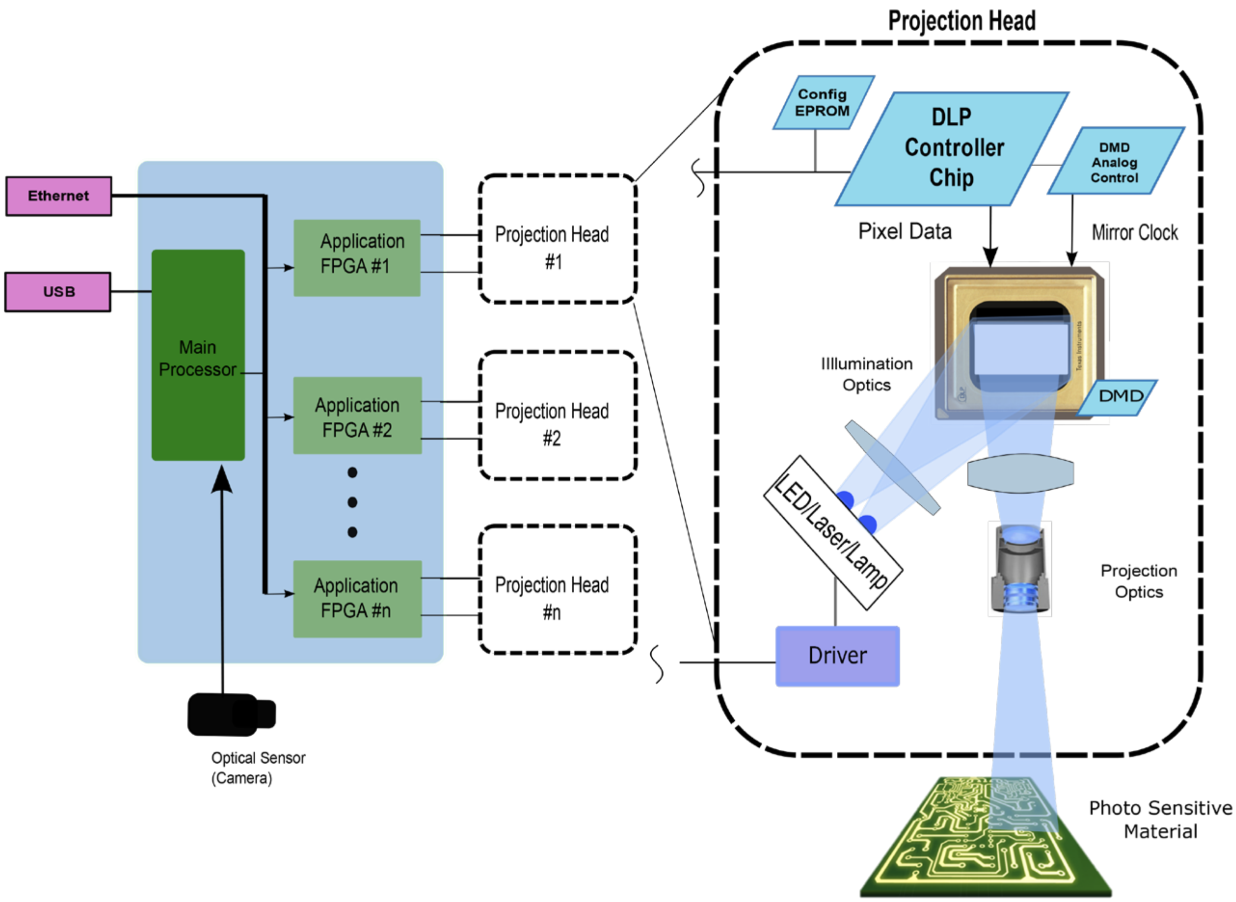

FIG. 2

This project has substantial challenges in both the electrical and mechanical systems, a few of which are as follows:

- The pixel count in the projector will likely not provide sufficient resolution over a large enough area. Thus the device may need to include a lensing system that downscales and columnates the light pattern, as well as an motorized bed similar to that of a 3D printer which moves the substrate and allows an array of patterns to be illuminated on the substrate.

- There needs to be a way to align the substrate below the projector with ~25 micron resolution (ideally ~5 micron) across the entire substrate. This may involve some combination of optics, mechanical actuators, and motors (e.g., linear actuators).

- The user interface should be straightforward and easy to use.

This device will be used as research tool in Prof. Theogarajan's lab.