"Fast" photolithograpy at zero cost (almost) using obsolete equipment

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Abstract

Often one needs a simple photolithographically produced pattern quickly, for example, to make electrical contacts to nanofibers. Because of constraints, such as fiber location, length or shape or the proximity of other fibers, the desired pattern has to be customized and may only be used once. While this can be done with laser writers or other specialized equipment, we propose a fast, zero-cost solution. Other relatively simple ways of doing this have been reported but are different from ours. [1,2]

In a now obsolete micrograph recording process the image from the sample is focused on the Polaroid film which is mounted on top of a cone shaped fixture attached vertically on the camera tube of the microscope. Why not reverse the process, and replace the film by a patterned transparency/mask, back light it, and project the image on a photoresist covered sample? It's not quite, but almost, that simple. Diffuse back lighting will lead to negligible light intensity on the sample. The light incident on the transparency needs to be converging toward, and ideally fill, the lens in the camera tube of the microscope. The layout of the optics is shown in See Fig. 1.

The "mask" is simply a transparency, such as was used for vu-graphs, now also obsolete, designed on a computer and printed on an ordinary printer. The lithography is "fast" in that the time to make the mask can be comparable to the time it takes to do the exposure. For a preliminary demonstration we printed three letters of various sizes in Arial font: M, W and I on a black background, and exposed the pattern using 10X, 20X, 50X and 100X objectives. The optimum exposure times which yielded the sharpest corners are shown in the table. An optical micrograph of the 20X exposure is shown in Fig. 2. The finest lines were 1mm on the transparency, and were resolved on the developed resist down to the 50X objective. As yet we have not optimized the process with the 100X objective to resolve the 1mm lines which should yield about 1μm lines in the resist. In typical operation we projected the image of the pattern to be exposed on the sample through a yellow filter, aligned to existing features by moving the microscope stage and then exposed by removing the filter. Since our Leitz Ergolux microscope is equipped with a 1μm precision X-Y stage we can also do manual step-and-repeat exposures. We will report on minimum dimension features that can be exposed, dimensional distortion in the field, contrast, alignment accuracy, and, most importantly, uniformity of illumination across the field.

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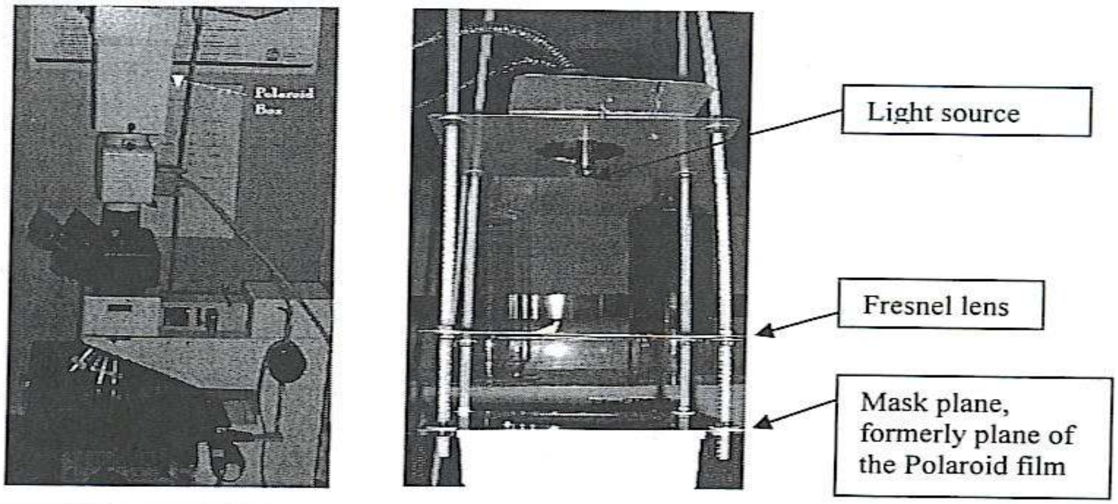

Fig. 1. (left) Leitz Ergolux optical microscope. The Polaroid camera normally is located on top of the structure labeled "Polaroid box". (right) The fiber light source, Fresnel lens, and mask structure that replaces the camera. All three elements are attached to four threaded nylon rods. The Fresnel lens has 11cm focal length and mounted 16 cm below a fiber light source. The mask, in the plane where the film was formerly located, is 7.5 cm below the lens, and the lens in the microscope camera tube is 35 cm below the mask

Magnification	Optimum Exposure Time (mins)
10x	9
20x	5.5
50x	2
100x	1.5

Fig. 2. Optical micrograph of pattern exposed at 50X.