Exposure of sprayed photoresist on KOH etched side walls of a silicon wafer with a Heidelberg Instruments DWL 66+

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MOTIVATION

When exposing photoresist on KOH etched sidewalls with a mask aligner, proximity effects result in structure widening that is not desired. Figure 1 shows a structure of lines and spaces, 25µm wide resist strips over a 500 µm deep silicon pit. The structures in the lower area of the pit (see Figure 2) are widened to approx. 55 µm due to the large distance to the chrome mask. The achievable structure resolution is to be improved by using the DWL 66+ laser direct writer from Heidelberg Instruments.
SUBSTRATE PREPARATION

Silicon wafers with KOH etched grooves of 500 µm depth were used for the developments shown in this application note. Resist deposition was performed with a spray coating procedure using a Spin-/Spray coater EVG101. As resist, AZ9260 was used, which was diluted by a solvent in order to obtain a mixture suitable for spray coating.

A typical feature of spray coating is a variation in the paint thickness over the pit flank (see Figure 3). The resist thickness can typically vary between 2 and 15µm over the sidewall. Therefore, an exposure series must be carried out in order to determine the best exposure dose. The dose must be sufficient to safely develop the resist, which is thickest in the lower pit area. However, the higher the dose, the more the resist structures at the upper edge are widened by overexposure as this is the spot with the lowest resist thickness.

Figure 3: Sideview of a broken wafer piece. A thin AZ9260 resist layer can be seen.

“BASIC FREEFORM” OPTION

An option for the DWL 66+ is available, which facilitates the exposure on non-flat surfaces, which are called “freeform” surfaces. Heidelberg Instruments modified the systems hardware and conversion software in such a way that the exposure across a KOH etched sidewall or a convex or concave surface profile is feasible.

At first, the structures must be drawn by a CAD program in 2D. The CAD file is then converted with the freeform software into a 3D design and an associated layer.ini, where the design is broken down into different depth layers.

The conversion software allows only the exposure onto the sidewall itself. If the structure is to be written on the outside, i.e. on the pit floor or to the wafer surface, a manual adjustment of the layer.ini is necessary. Both the focus position and the dose can be adjusted as parameters.
RESULTS

In Figure 4, lines and spaces with widths between 5 and 30 microns were realized. These structures were exposed on a sidewall of a KOH etched recess with a depth of 500 µm. For the exposure job, the layer.ini was adapted in such a way, that the structures could be prolonged on both side of the sidewall. The detail in Figure 5 shows the lower edge of the pit and demonstrates the resolution enhancement when compared to the irradiation with a mask aligner (see Figure 2).

Figure 4: Lines and spaces with widths between 5 µm to 30 µm across a 500 µm KOH-edge

Figure 5: Detail from Figure 4
RESULTS

An appropriate design was set up to build a meander structure with a line width of 20 µm (Figure 6). The same design with inverse tone can be seen in Figure 7, respectively. In Figure 8, the Fraunhofer logo was realized on a KOH etched sidewall as metal structure.

With the help of HIMT’s DWL 66+ laser direct exposure system and the freeform software extension, the focus can be adjusted during exposure to a KOH-etched silicon sidewall, enabling much higher structure resolutions than with a mask aligner.

Figure 6: meander structure with 20 µm wide tracks across a 500 µm deep KOH sidewall
Figure 7: same as in Figure 6, but with inverse tone
Figure 8: Fraunhofer logo gold structure made by lift-off technique