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2000s

Sophisticated resolution techniques

~ Process Technology ~

In the conventional method, it has been possible to downsize only to the wavelength of the light source used for exposure, and various techniques for further improvement of the resolution have been developed. The major technologies of resolution enhancement are ①oblique incidence illumination technology, ②phase manipulation of light on a mask, ③advanced correction of patterns on masks, and ④divisional processing of complex patterns. The idea of these technologies began around the 1980s, efforts for practical application were made by many research and development engineers engaged in microfabrication, and it was partially put to practical use in the 1990s. While the exposure light source after ArF is unclear, various efforts are still being made in even more advanced miniaturization technologies.

① To Illuminate the mask obliquely, discarding one of the diffracted lights which expand to two sides after passing through the mask (order 1 / order -1), and capturing as much as of the other (used) light, thereby imaging with two light fluxes (order 0 and order 1) to make the depth of focus deeper. As a device, it is realized by inserting a filter that transmits light in the optimal arrangement in the peripheral part of the illumination diaphragm opening (Fig. 1).

② It is called a phase shift mask, and there are two types, Shibuya-Levenson type (alternate type) and half tone type (attenuated type). The techniques are the same between these two types in that the phase of adjacent lights transmitted through the pattern on the mask are reversed, thus improving the contrast of the image. The difference is that while in the former method, the 180 ° phase inversion shifters are provided in the adjacent transmitting parts on the mask, and in the latter the light to be shielded in the normal mask pattern arrangement is partially transmitted (half tone) and phase is inverted (Fig. 2). In the practical application, the important points are two folds, especially in the former type, the automatic arrangement for sequentially setting the phase of the light transmitting portion of the pattern on the mask in 0 - n, and the technique of detecting the mask phase defect.

③ It is generally called OPC (Optical Proximity Correction). The transferred image of the original pattern is defined by both simulation and experiment, and the difference of their parameters are extracted, and it is reflected in the original design layout data. In around 1990, it was manually done by design engineers in some part of design, and it is now possible to automatically generate correction data on the whole chip.

④ A pattern is divided into two patterns that can be resolved by the exposure apparatus, and the fabrication process is also done in two steps. In the case of repeated patterns like in memory devices, a pattern is formed on both sides of the side walls of the formed repeated pattern, thus making the

half pitch pattern. It is called double patterning. Although it is possible to form a pattern below the resolution limit of the exposure tool, an increase in the manufacturing cost is a problem due to the increase in the number of processing steps and an increase in the mask cost.

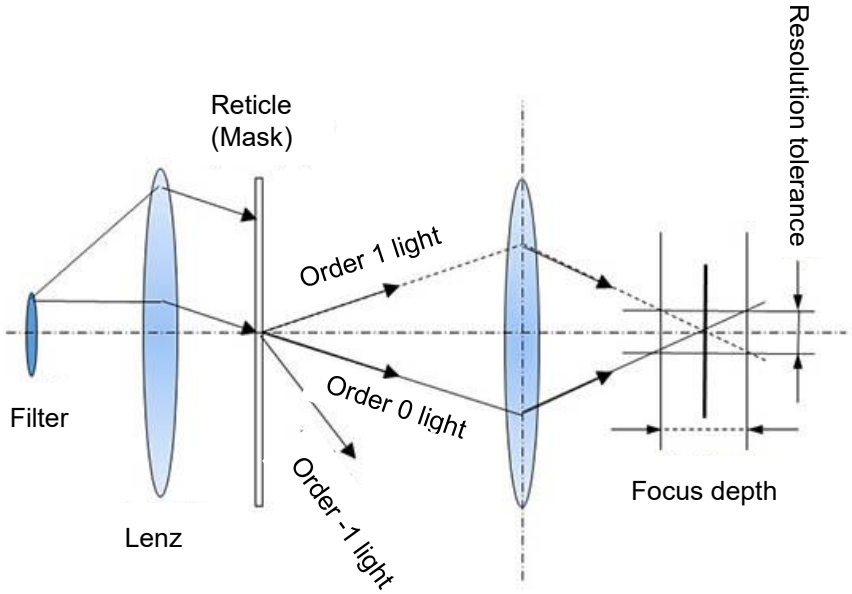

Fig. 1: Oblique incidence illumination technology

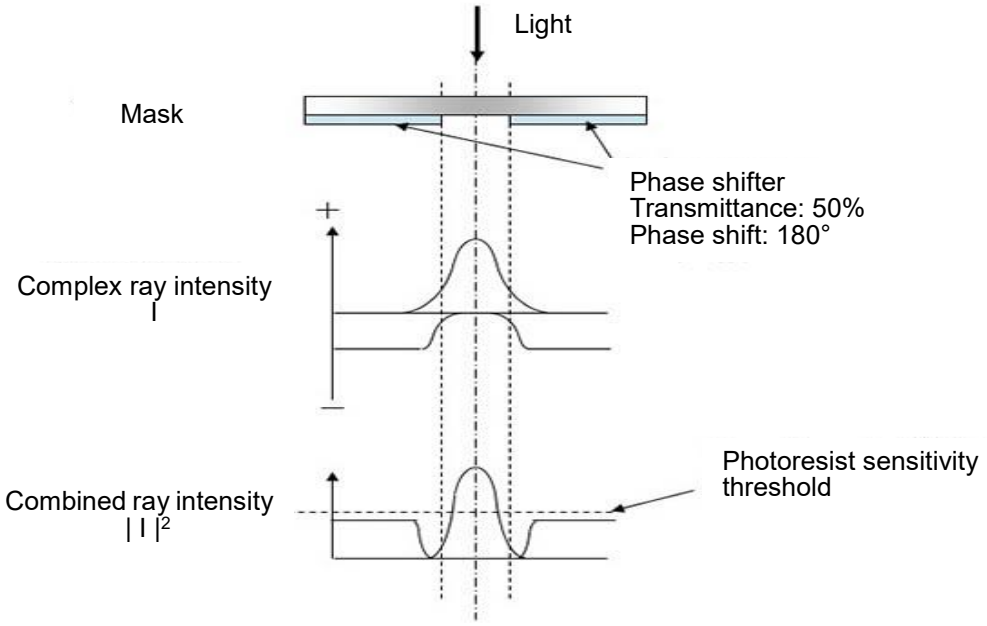

Fig.2: Half-tone phase-shift technology