

## 1960s

### **Manufacture of silicon devices by using contact lithography**

#### **~ Process Technology ~**

In the 1960s, silicon transistors and silicon ICs were manufactured using planar technology. The planar technology is a technique for forming a PN-junction by forming an SiO<sub>2</sub> thin film on the silicon surface by thermal oxidation, opening windows in the SiO<sub>2</sub> film through which the dopant is diffused into Si. By using planar technology, manufacturing of transistors with stable characteristics became possible, and the semiconductors made a great progress to ICs by the integration of the transistors

The process technology that forms the basis of planar technology is photolithography (often referred to simply as lithography) technology. This technique is basically the same as the printing of a photograph, and a plate with patterns (corresponding to a negative of a photograph) called a mask is brought into close contact with a silicon substrate coated with a photosensitizer (called a photoresist), exposed and developed.

Since the mask is brought into close contact with the silicon substrate, this method is called contact lithography (a technique that does not bring the mask into close contact came to be used later, so it is called contact lithography to distinguish it from the non-contact type). The developed photosensitive agent has chemical resistance, thereby becoming the protective mask against the chemical etching with its pattern to form the openings in the SiO<sub>2</sub> film, Al electrode and so on. Lithography processes are repeatedly done, and it is necessary to do the position alignment of a photomask to the previous pattern. The equipment used for this is called an aligner. Basically, the aligner consists of a light source, a microscope and an XY stage for the alignment work.

Initially, Japanese manufacturers had performed lithography processes by combining handmade XY stage and microscope, but when an aligner was released from the Kulick & Soffa in the US in 1965 that integrated these functions for easy alignment operation, they purchased the equipment and used them for mass production. In addition, the photoresist was imported from Kodak of the US, and Japan still relied on the US for the main equipment and materials in this era.

The original mask plate was called an emulsion mask because it was made by coating a photosensitive emulsion on a glass plate and printing the pattern on it. Printing of the pattern was carried out by cutting out the pattern from a red sheet called Rubylith (ruby paper), which was exposed by reduction projection Camera and developed.