

1980s

g-line stepper

(reduction-projection exposure system)

~ **Discrete Semiconductor/Others** ~

The reduction-projection lithography (stepper) system had been announced by GCA in 1978 (DSW4800), and Nikon delivered a stepper called (VL-SR2) to the VLSI Technology Research Association in the same year. Nikon commercialized a stepper called (NSR-1010G) with a resolution of 1 μm in 1980. (Figure 1) Both were steppers with a reduction ratio of 10:1 using g-line, and were significantly effective in reducing defect density compared with the projection exposure method used until then. On the other hand, the step-and-repeat method had lower productivity than the projection exposure method, limiting its application as an exposure system for mass production. Furthermore, there were many problems in achieving resolution in the sub-micron region of 1 μm or less. Therefore, steppers had been considered as a bridge lithography technology in transition period to X-ray and EB lithography methods.

Nikon developed an optical system with a reduction ratio of 5:1 and an expanded exposure area of 15 mm x 15 mm, and released a g-line stepper (NSR-1505G, NA=0.3, resolution of 1.2 μm) with significantly improved productivity in 1981. The throughput was nearly three times higher than the previous stepper with a reduction ratio of 10:1 and an exposure area of 10 mm x 10 mm. It was used as a stepper for mass production of the 1.3 μm generation. GCA launched a 5:1 stepper (6300DSW) in 1983, and Canon also launched a 5:1 stepper (FPA-1500) in 1984. The 5:1 reduction ratio became the standard technology for stepper systems, and at the same time, it opened the path for resolution improvement of optical systems through the investigation of optics.

Since the resolution of optical lithography is proportional to λ/NA (λ : wavelength of light, NA: Numerical Aperture), shorter wavelength of light or higher NA (or both) was required to achieve submicron resolution and/or shorter wavelengths was required correspondingly more sensitive photoresists. Therefore, Japanese companies such as Nikon and Canon took the lead in developing a high NA optics to keep the exposure area of 15 mm x 15 mm for the 0.8- μm generation in accordance with the above. Canon developed a g-line stepper (FPA-1550MII) with NA=0.43 and 0.8 μm resolution in 1986 and Nikon developed a g-line stepper (NSR-1505G4D) with NA=0.45 and 0.75 μm resolution in 1987.

Steppers required high-precision automatic positioning mechanisms using high precision lens and laser interferometers. Once steppers were adapted as the standard, mass production technology for several hundred units per year was essential. Recent years, Nikon and Canon, which have the advantages of both, have occupied 70%-80% share in the world market.



Fig-1 10:1 stepper (NIKON NSR-1010G)
(Courtesy of Nikon Corporation)

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