1 Photolithographie

1.1 Exposition methods

1.1.1 Overview

There are different types of lithographic methods, depending on the radiation used for exposure: optical lithography (photolithography), electron beam lithography, x-ray lithography and ion beam lithography.

In optical lithography patterned photomasks (reticles) with partial opaque and partial translucent areas are used. The exposure with ultra-violet radiation or gas lasers is done in a scale of 1:1 or reducing in a scale of 4:1 or 10:1 for instance.

1.1.2 Contact exposure

Contact exposure is the oldest used method. The photomask is in direct contact to the resist layer, the structures are transfered in a scale of 1:1. Thus disruptive scattering or diffraction effects only appear at the edges of the structures. This method allows only moderate feature sizes. Because all chips are exposed simultaneously the wafer throughput is very high, the construction of the lithographic unit is simple.

However, the disadvantages are obvious: the mask is contaminated because of its contact to the resist and can be scratched as well as the resist layer can be damaged. If there are particles between the mask and the resist, the optical imaging is degraded.

1.1.3 Proximity exposure

In proximity exposure there is no direct contact of the photomask and the resist. Thus only a shadow image is projected onto the wafer which results in a much worse reso-

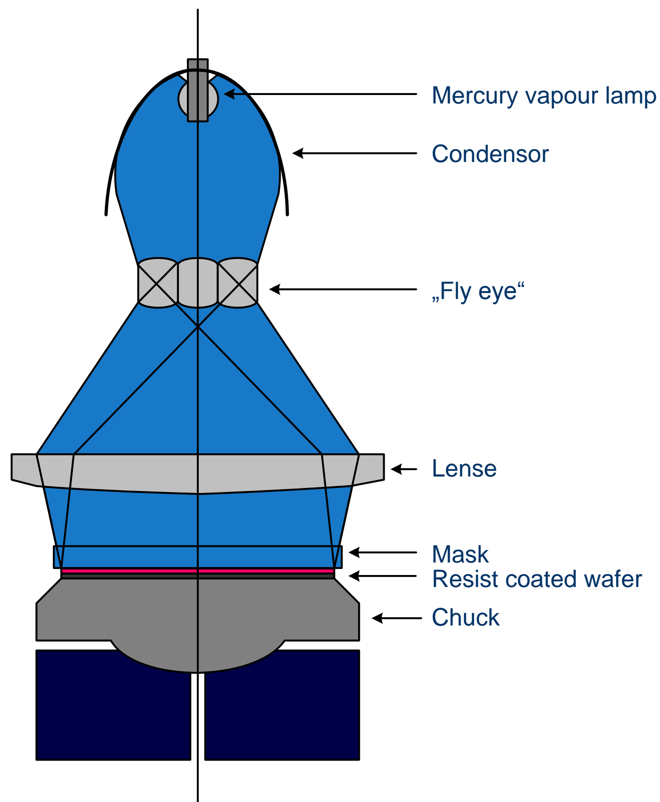

Fig. 1.1: Contact exposure

lution of the structures, contact issues are prevented therefore.

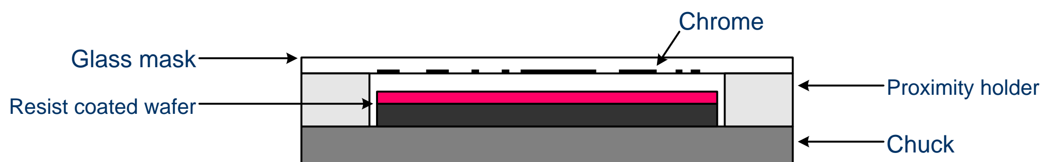

Fig. 1.2: Proximity exposure

1.1.4 Projection

The exposure via projection uses the so-called step-and-repeat technique. Thereby only one or a few dies were projected onto the wafer at a time. The entire wafer is exposed step by step - die by die.

The advantage of this method is that the structures on the reticle are enlarged 4-fold or 10-fold. If the structures are projected onto the wafer in reduced scale, also defects,

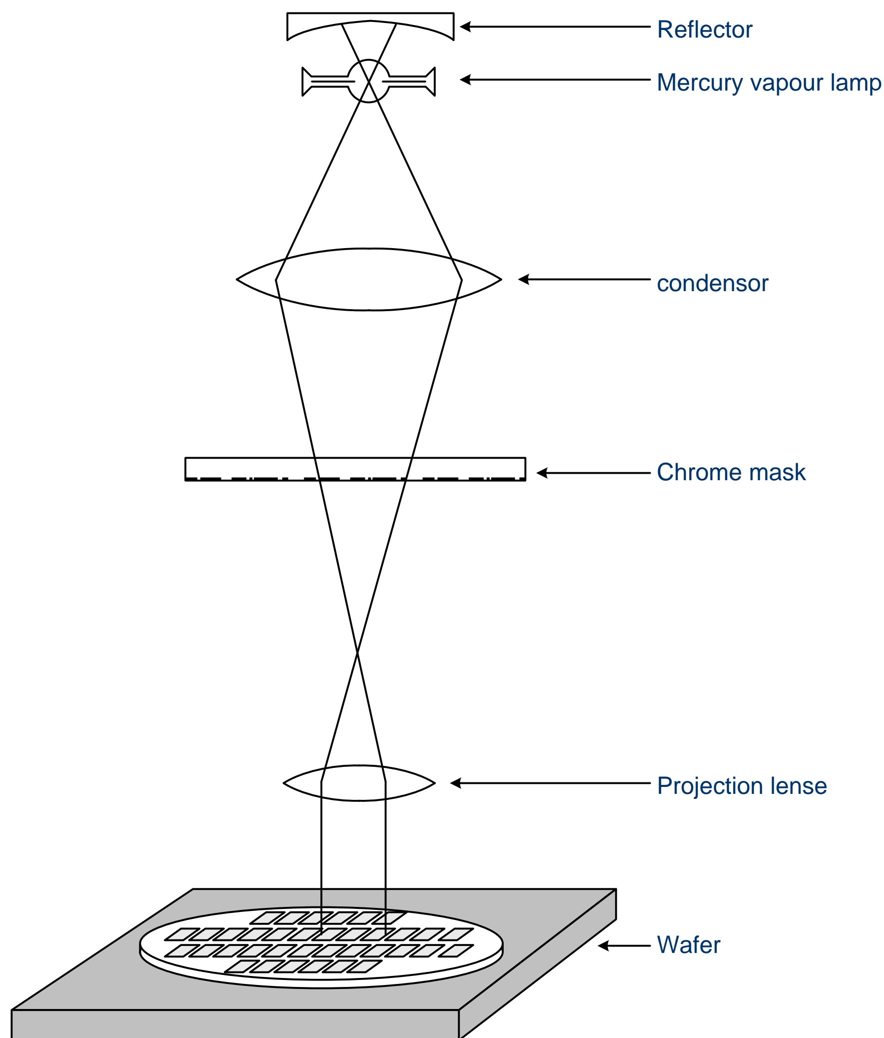

Fig. 1.3: Step and repeat technique

like particles, are reduced. In contrast to other exposure methods the resolution is improved.

In addition a thin foil - pellicle - is attached to the mask, and therefore particles will be held off the mask and are out of focus during projection.

Besides the projection with lenses also a projection with a complex system of mirrors can be used (scale 1:1). Compared to lenses there are no color aberrations and thermal expansion of the photomask can be adjusted. However, mirror images can be distorted or warped. The resolution is limited due to the scale of 1:1.

1.1.5 Electron beam lithography

As in photomask manufacturing a focused ion beam is scanned across the wafer, the scan is done line by line. Each structure has to be written one after the other which takes a lot of time. The advantage is that there is no need of photomasks which reduces the costs. The process is done under a vacuum.

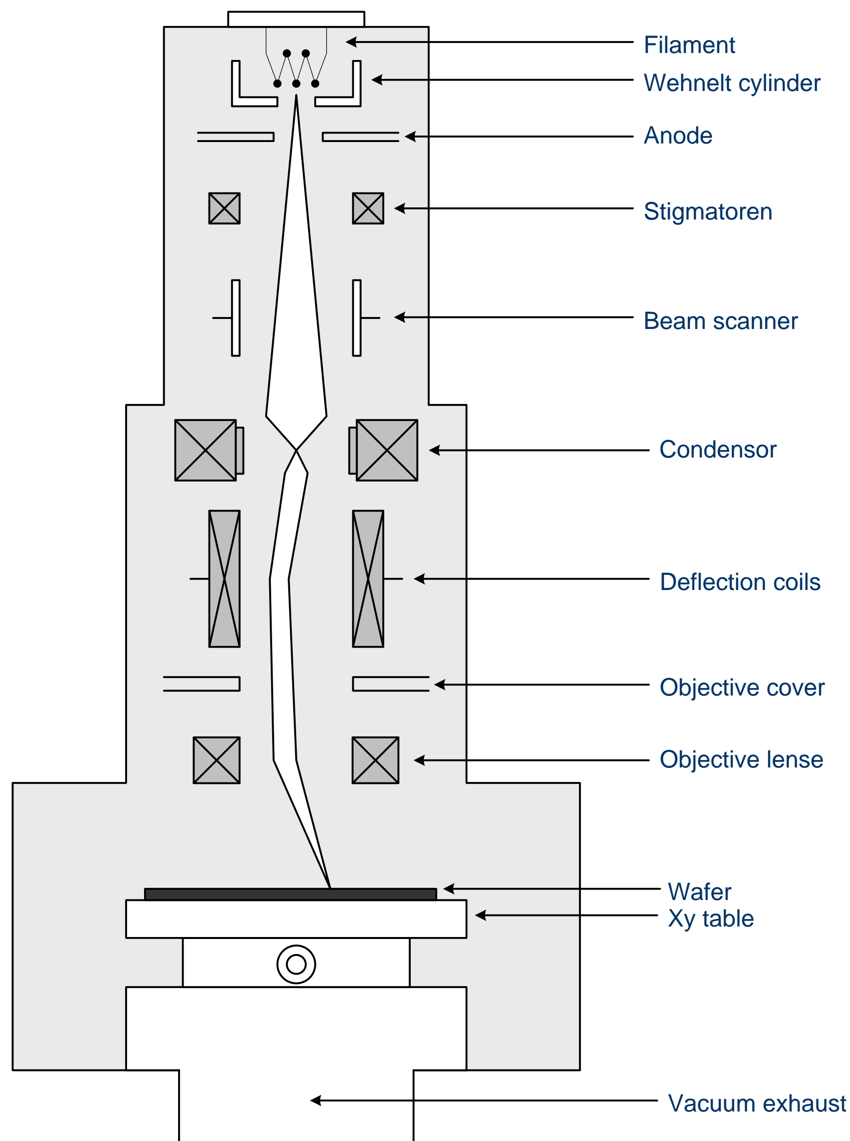

Fig. 1.4: Electron beam lithography

1.1.6 X-ray lithography

The resolution of x-ray lithography is about 40 nm. The imaging is done in step-and-repeat technique in a scale of 1:1 in atmospheric pressure or low pressure in helium atmosphere (about 10.000 Pa). The x-ray source can be a plasma or a synchrotron.

Instead of chrome coated glass masks, thin foils made of beryllium or silicon are used. To adsorb x-rays heavy elements like gold are necessary. The facility as the photomasks are very expensive.

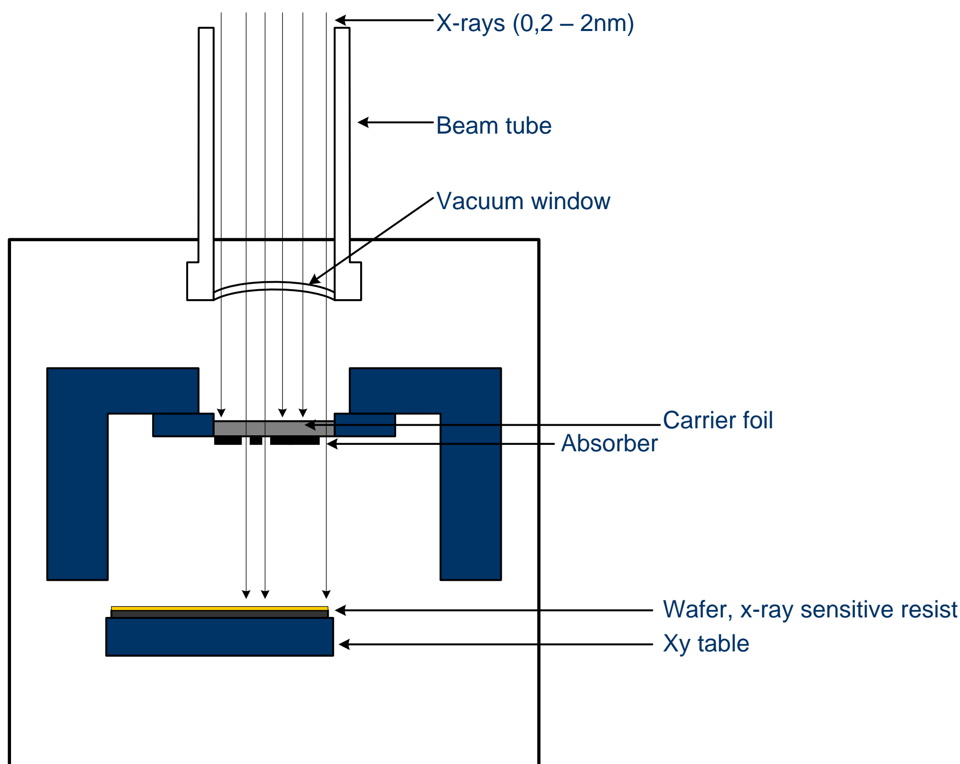

Fig. 1.5: X-ray lithography

1.1.7 Additional methods

An additional method of lithography is the use of ion beams. The wafer can be exposed with a photomask or, like in electron beam lithography, without a mask. In case of hydrogen ions the wavelength is about 0.0001 nm. Other elements allow a direct doping of the wafer without the use of masking layers.