1 Photolithographie

1.1 Development and inspection

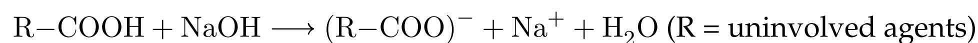
1.1.1 Development

The exposed wafers are developed in dipping baths or in spray processes. While dipping baths allow the development of multiple wafers at a time, in spray development one wafer is processed after another. As in resist coating processes the wafer is placed on a chuck and sprayed with developing chemicals while rotating at low rpm. Subsequent the wafer development process is stopped with water.

Some advantages of the spray development in contrast to dipping baths are:

- smallest structures can be developed
- the chemical is renewed steadily
- the amount of chemicals is much less

Depending on the type of resist - negative/positive - exposed areas are solubly or insolubly in developing chemicals and a patterned wafer remains after development. The exposure causes a chemical reaction in the resist thus that the sensitizer forms an acid which is neutralized by the developer like follows:



$$\mathrm{R{-}COOH + NaOH \longrightarrow (R{-}COO)^- + Na^+ + H_2O} \text{ (R = uninvolved agents)}$$

Because potassium hydroxide or sodium hydroxide leave residuals on the wafer, chemicals without metal ions, like TMAH (tetramethylammonium hydroxide), are used. An additional annealing (hard-bake) hardens the resist to be resistant to subsequent etch processes or ion implantation.

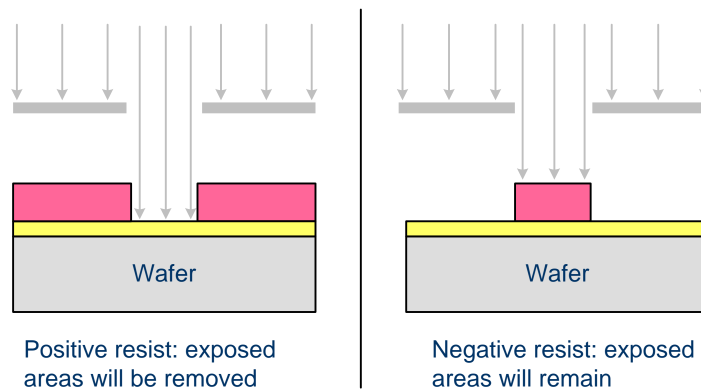


Fig. 1.1: Illustration of positive and negative resist after development

1.1.2 Inspection

The resist has to be inspected afterwards. In angular incidence of light the uniformity of the layer can be inspected as well as bad focusing or agglomeration of resist. If structures are too thin or too wide the resist has to be removed and the process has to be repeated. The resist pattern has to be adjusted precisely to the layer beneath or the process has to be repeated as well. Different alignment marks are used to investigate the adjustment and the line width.

The line width is inspected with a microscope: light rays incidence in perpendicular direction onto the wafer and will not be reflected into the objective from edges. Thus the edges appear as dark lines which can be used to calculate the line width and distance to adjacent lines.

1.1.3 Resist removal

After the pattern has been transferred into the layer beneath in etch processes, or after the resist mask was used in ion implantation, the resist has to be removed. This is done with abrasive chemicals (remover), in a dry etch step or with solvents. As solvent acetone can be used since it does not corrode other layers on the wafer. Due to a dry etch process or ion implantation the resist could be hardened, so that solvents can't remove it.

In this case the resist can be removed with a remover dilustion at about 80 °C in a dipping bath. If the resist has been heatened above 200 °C even the remover can't remove it. In this case the resist has to be removed in an ashing process.

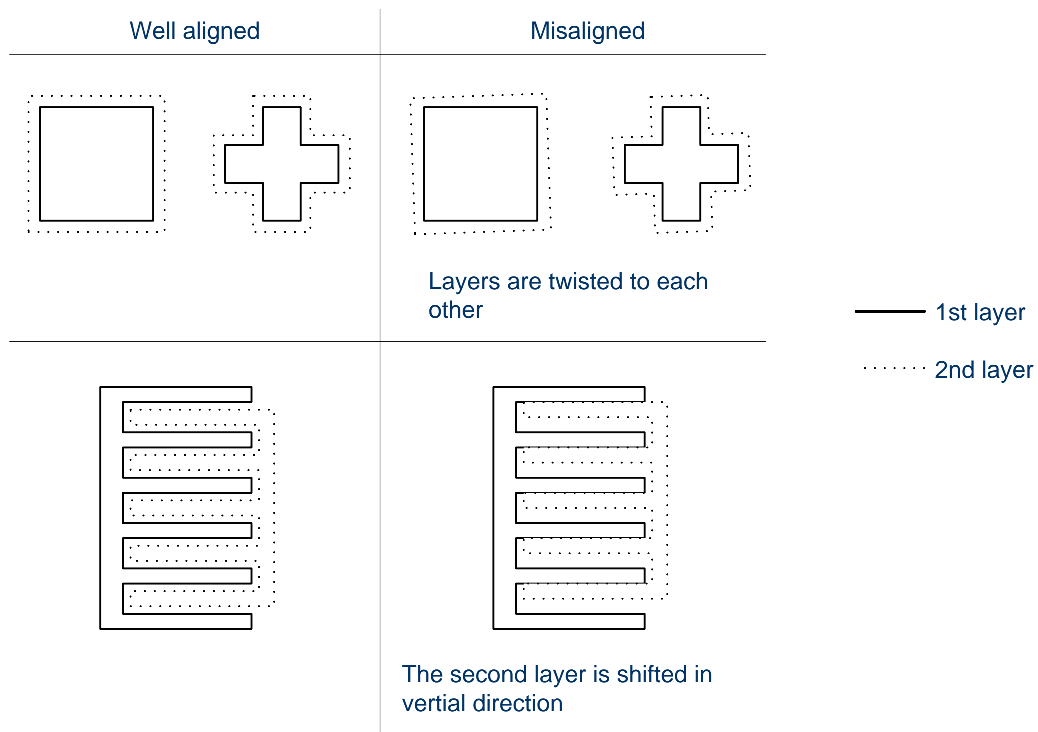


Fig. 1.2: Illustration of alignment marks

Under oxygen ambient a gas discharge is ignited by high frequency, thus energetic oxygen atoms are generated. These atoms can ash the resist residue-free. However, charged particles can be accelerated in the electric field an cause damage to the wafer surface.