Photolithography Exposure Modes

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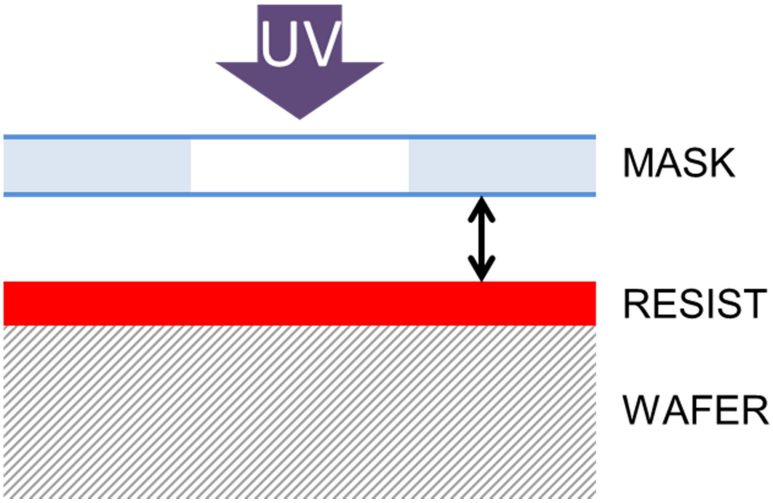
KNOWLEDGE BASE FACT SHEET

- SCOPE: A guide to photolithography, mask aligner exposure modes.

This Inseto Knowledge Base document introduces the Mask Aligner Exposure Modes used in photolithography. The basic steps of photo lithography as used in microfabrication, are outlined in a separate document: Lithography Basics.

In this guide, some more detail will be given on the exposure of a coated wafer or substrate and how this affects your lithography process.

A mask aligner is utilised in photo lithography to align the coated wafer with a mask and then to expose the wafer to UV light through the mask, as shown:



Typical exposure of wafer and mask within a mask aligner.

When exposing the coated substrate to the UV light, there are a number of options available to the user called exposure modes.

Through the mask aligner, the operator is able to precisely control the height of the gap between the mask and the wafer, called the “exposure gap”. Increasing or decreasing this gap will impact on the final resolution of the patterned substrate but also the throughput of the fabrication process.

The exposure modes can be split into two groups: contact and proximity exposure.

Commonly used contact exposure modes are:

- Soft contact
- Hard contact
- Vacuum contact
- Low vacuum contact

In contact mode, the mask and the wafer are, as the name suggests, brought into contact and then held parallel to one another through a process called wedge error compensation (WEC). The wafer and mask are then moved to the alignment gap and positioned relative to one another. Once alignment of the mask and the wafer has been completed, they are then pressed together and exposed to the UV light. The extent to which they are pressed defines the exposure mode and the resolution achievable.

Exposure Mode: Soft contact
In soft contact the wafer and mask are only just brought into contact and no further force is applied.

Exposure Mode: Hard contact
In hard contact, the wafer and mask are brought into contact and then an external force or pressure is applied to press them into one another. The amount of force used should be defined by the operator.

Exposure Mode: Vacuum contact
In vacuum contact, the wafer and mask are pressed together as in hard contact, but then a vacuum is pulled between the wafer and the mask bringing them closer together. This results in the highest resolution results. Low vacuum mode (sometimes referred to as soft vacuum mode) reduces the impact on the wafer and mask when the vacuum is pulled. This is particularly useful if brittle substrates are being used that are liable to break.

Exposure Mode: Proximity
The alternate to contact exposure is to use proximity exposure. Here the mask and wafer never touch and are held apart from one another. The exposure gap setting can range from a few microns up to 100s of microns, depending on the quality of the mechanics and optics within the mask aligner in use. Within a proximity exposure even the WEC is carried out without the wafer and mask touching.

As we move from proximity; to soft; to hard; to vacuum contact the resolution achievable increases. This is because as the wafer and mask are brought into contact, the diffractive effects from mask to air and air to substrate (which lower resolution) are minimised / removed, until the exposed pattern more precisely matches that of the wafer.

However, repeated contact exposures increase the risk of contamination and damage to the mask. This could be from particles transferred from the substrate to the mask in the form of dust, or other organic and inorganic contaminants; partially baked photoresist residue from the substrate can also stick to the mask. In these circumstances, the fidelity of the pattern is compromised and the yield on the substrate is lowered. To overcome this contamination, the mask must be cleaned after a set number of exposures.

Advances in the optics within the mask aligner have led to improvements in the resolution achievable at large gaps, making proximity exposure the most common exposure mode used in a production environment today.