Optics of Photolithography of [Optical Lithography]

Photolithography is the process of transferring patterns of geometric shapes on a mask (or reticle) to a thin layer of PR covering the surface of a semiconductor wafer. The resist pattern defines by the lithography process are not permanent element of the final device, but only replicas of circuit features. The pattern transfer process is accomplished by using two kinds of the lithography exposure tools: Pattern Generators and Pattern replicators.

A pattern generator is an exposure tool that accepts pattern input data from a database and directly creates a physical Image on wafer using beams of Ether charged particles or photons. These tools are used extensively to create photomasks and reticles for pattern replicators. They are also used in limited volume for direct patterning on semiconductor wafers.

The main disadvantages in using pattern generators for general purpose high volume lithography is the slow Imaging on the wafer. The required patterning density is on the order of $10^{13}/cm^2$ discrete pixels for a features size of $\sim 65\,nm$. The achievable speeds for e^- or photon pattern generator are less than 100 pixels/s, leading to imaging rates of no more than one 200mm wafer per hour. The general rule for economical semiconductor production requires a wafer patterning tool to

process on the order of 100 wafers per hours or higher, and existing direct pattern generators simply cannot come close to achieving this speed.

The solution to the throughput limitation of pattern generators is to create a master pattern image in the form of a photomask or reticle and then replicate the pattern in a massive parallel fashion onto the wafers. Photomasks consists of a fused - silica substrate covered with a chromium layer. Photomasks fabrication is performed with electron beam and photon beam tools, while repair of mask pattern defects is performed with ion beam and photon beam tools.

Pattern replicators use a variety of image transfer technologies, including photons and charged particles. The most common pattern transfer agent is a well-conditioned beam of monochromatic photons. Exposure wavelengths used in photolithography are form the far uv (100nm to 290nm) and near uv (320nm to 450nm) protions of the electromagnetic spectrum. Systems with board spectrum lamps or "breadband" systems typically emit wavelengths that span roughly the 350 nm to 450nm wavelength that span roughly range. Example of such a system is a high pressure mercury arc lamps; its spectrum is shown in figure. The first practical

step and repeat imaging tools used the so-called G line of mercury at 436 nm wavelength ~~in figure~~. Second generation stepper tools used the I-line of mercury at 365 nm.

More recently, as the need for higher resolution drove the requirement for wavelength down, mercury arc lamps were replaced by excimer laser. The lasers provide both very high intensity and very narrow bandwidth. The most advanced exposure tools in the semiconductor manufacturing employ a short wavelength of 193 nm, generated with the help of ArF excimer lasers.]

Note :- Exposure Method :- Pattern Replicators can be classified by two exposure method :- shadow printing and projection printing. Shadow printing may have the mask and wafer in direct contact with one another (contact printing) or in close proximity (proximity printing) as illustrated in figure 1. In this module, we will use the contact printing method. As shown in figure 1(a) in contact printing a resist-coated wafer is brought into physical contact with a mask. Resist is then exposed with a nearly collimated beam of ultraviolet light through the back of the mask for a fixed time.

The intimate contact between resist and mask provides a resolution of approximately 1μm. It is important to realize that the contact printing suffers a major drawback caused by dust particles. The imbedded particle

cause permanent damage to the mask or result in increasing defects in the wafer with each exposure.

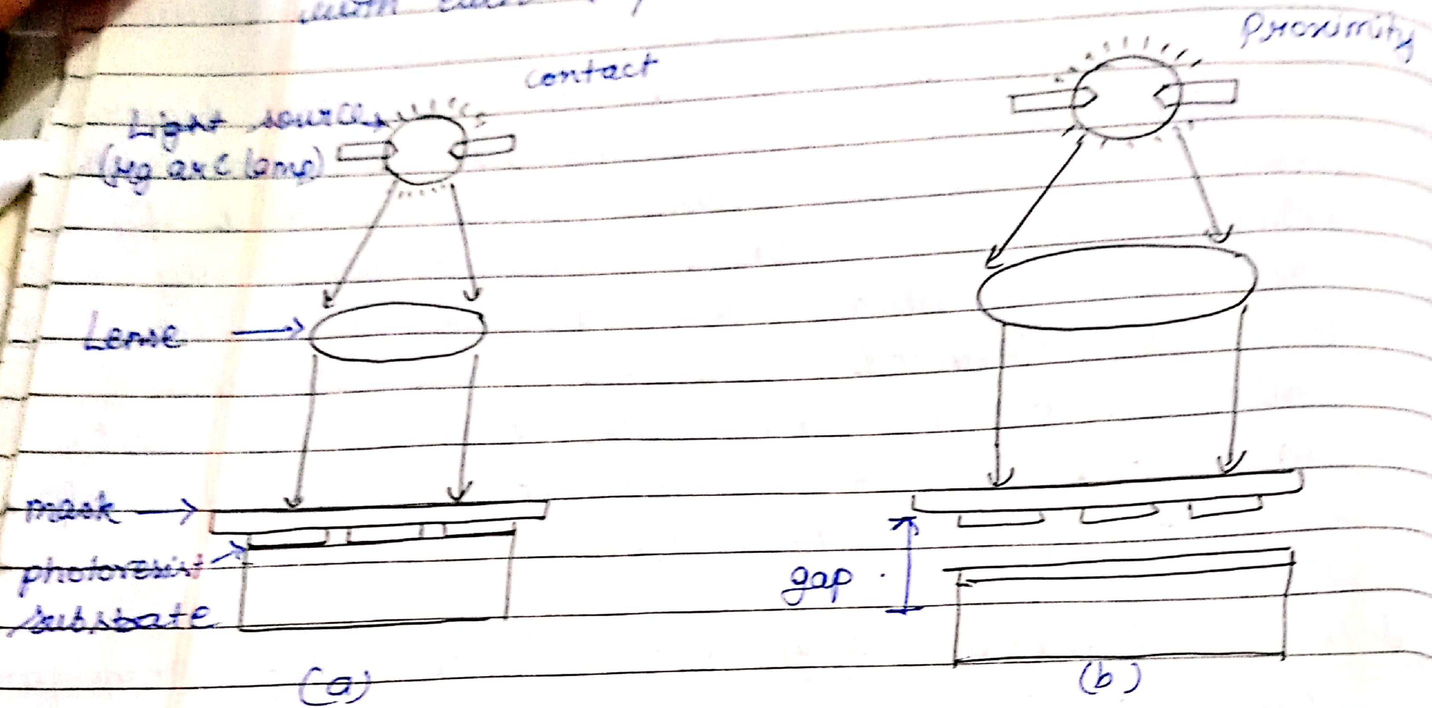

figure 1 :- schematic diagram of optical shadow printing technique :- (a) contact printing
(b) Proximity printing.

⇒ Steps Involved In The Photolithography Process

Every PR has its own instructions manual (datasheet or recipe) generally, provided by its manufacture. However, it is necessary for every laboratory to test the recipe offered by the manufacture and create its own recipe adapted to the specific laboratory condition (i.e; temperature, humidity, process interest and equipment characteristics). A general flow chart of the microlithography process can be seen in figure. ~~The~~

Step	Description
Prime	decrease the likelihood of features lifting during development.
Spin-coat & bake	The resist is spin-coated & the solvent is evaporated by baking the wafer in hot plate.
Expose	The resist is exposed & a latent image generated
Post-exposure bake	In some resists a bake after the exposure enhances the process performance.
develop	The latent image is developed forming a relief pattern
Hardbake	Batting the wafer after development can improve thermal stability of the relief pattern.

Flow chart of the photolithographic process. The post-exposure and Hard Bake steps can be omitted, depending on the process.

(5)

Question- Give Block Diagram of Vaccum Coating unit. and explain the following in detail.

1. Rotary Pump
2. Diffusion Pump
3. Pirani Gauge
4. Penning Gauge.

Solution :- Vaccum Coating unit :- In the present study a 0.3m conventional vaccum coating unit (12A4... Hind Hivac, India) was used for the film preparation. fig 1 shows the shematic diagram

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