Photopolymers and Photoresists:-

A polymer or plastic whose physical or chemical properties change when exposed to light is known as photopolymer.

A photopolymer consists of a complex mixture of polymers / oligomers / monomers which can be selectively polymerized and / or cross linked upon image wise exposure to light radiation such as UV light.

Photoresists :-

Photoresists are photosensitive materials, which after photoimaging and subsequent processing, resist action of certain chemicals in desired areas.

Let us consider a substrate which is covered by a thin layer of photoresist material. When the coating is selectively irradiated with light through a mask, the irradiated regions undergo changes (like cross-linking or polymerization or degradation). Depending on the type of photoresist material used, it is possible to wash away either the exposed or unexposed regions selectively, using a fluid, called the developer.

In positive photoresist, the light-exposed areas become more soluble in the photoresist developer and the portion of photoresist unexposed to light ~~become~~ remain insoluble.

In negative photoresist, the light-exposed regions become relatively insoluble in the photoresist developer and unexposed regions become soluble in the photoresist developer.

Eg. for a positive photoresist is Novolac polymer

Negative photoresist - polymers having UV-sensitive groups like chalcone, cinnamate, styryl acrylate etc.. in the main back bone chain or side chain.

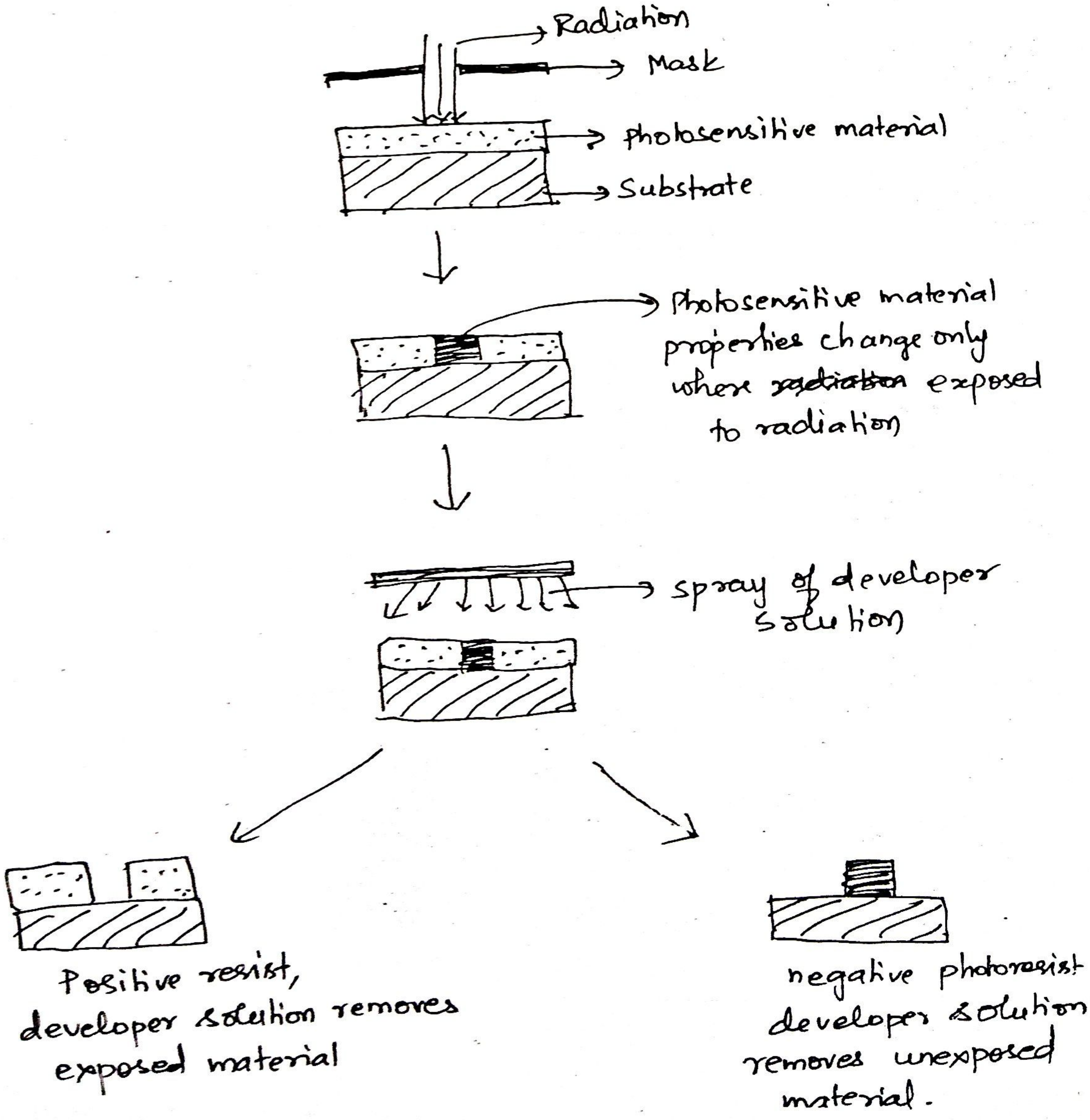
(26) Applications :-

(1) One common use of photopolymer is stereolithography, a three dimensional printing process that fabricates a solid object from a computer image.

(2) They are used to make stamps.

(3) Photopolymer plates are easier to design and they require less maintenance. Hence, they are used as printing plates instead of traditional lead or Magnesium plates.

(4) Photoresists are used in the production of printed circuit boards where they aid in the etching of copper from selected areas in the boards.



Additional Material for Photo Lithography – Photoresist polymer

16 Polymers for the Electronics Industry

16.1 INTRODUCTION

The application of specialty polymers in electronics and photonics is extensive, both in a "passive" role — when they act as insulators, encapsulating agents, adhesives, and materials for integrated circuit (IC) fabrication — and in an "active" way as electronic and photonic conductors, or as active material in nonlinear optics.

Some of these uses are rather mundane, in a chemical sense, but are necessary as an integral part of the whole process, e.g., in the packaging and protection of fragile ICs to avoid damage or to prevent the detrimental effects of humidity and corrosion. Epoxy novolacs or silicone-epoxy thermosetting resins are ideal for these purposes and are used to encase the IC that may already have been treated with a barrier coating of room-temperature vulcanizing (RTV) silicone rubber to prevent moisture absorption. Other applications are more interesting to the chemist as they require thought and ingenuity in the molecular design of the polymer.

The properties of polymers that make them an essential part of microelectronics engineering will be discussed under two main headings: polymer resists and conducting polymers. These will best illustrate why progress in this area could not have been made without exploiting the unique features of polymeric materials. This will be followed by a brief discussion of some photonic applications.

16.2 POLYMER RESISTS FOR IC FABRICATION

ICs are arguably among the most important products of the modern electronics industry. They are built up from various arrangements of transistors, diodes, capacitors, and resistors that are individually constructed on a flat silicon or gallium arsenide substrate by selective diffusion of small amounts of materials into particular regions of the semiconductor substrate, and by metallization of the paths linking the active circuit elements. The patterns defining these regions and the linking pathways must first be drawn by a lithographic process on a layer of resist material, and then transferred onto the substrate by an etching process. In this context, the *lithographic process* is the art of making precise designs on thin films of resist material by exposing them to a suitable form of patterned radiation, e.g., ultraviolet, electron beam, x-ray, or ion beam, with the formation of a latent image on the resist that can subsequently be developed by treatment with solvents or plasma. The *resist* is a material, usually polymeric, that is sensitive to, and whose properties (either chemical or physical) are changed by exposure to the electromagnetic radiation. It must also be resistant (hence, the name), after development, to the etching process and protect the areas it still covers, while allowing the exposed regions of the substrate to be attacked. In this way, a pattern is transferred into the substrate and the remaining resist material is removed.

16.3 THE LITHOGRAPHIC PROCESS

Several steps are involved in the lithographic process, and these are shown schematically in Figure 16.1. If the substrate chip is silicon, it is first oxidized to produce a thin surface layer of SiO_2 (step 1). A solution of the polymer resist is then spun evenly onto this surface and baked to remove the solvent and form a thin film of the resist (step 2), approximately 0.5 to 2 μm thick. The next stage (step 3) is the exposure of the resist to electromagnetic radiation either through a patterned mask or by direct "writing" if the radiation source is an electron beam. Depending on the radiation and the nature of the polymer resist, the exposed regions are either rendered soluble if the polymer is degraded — this is called a *positive-acting resist* — or insoluble if the polymer is cross-linked — this is called a *negative-acting resist.* A positive or negative pattern can then be developed by treatment with solvents that dissolve the exposed regions in the positive resist (step 4a), or the unexposed regions in the case of the negative-acting resist (step 4b), so producing the template for the

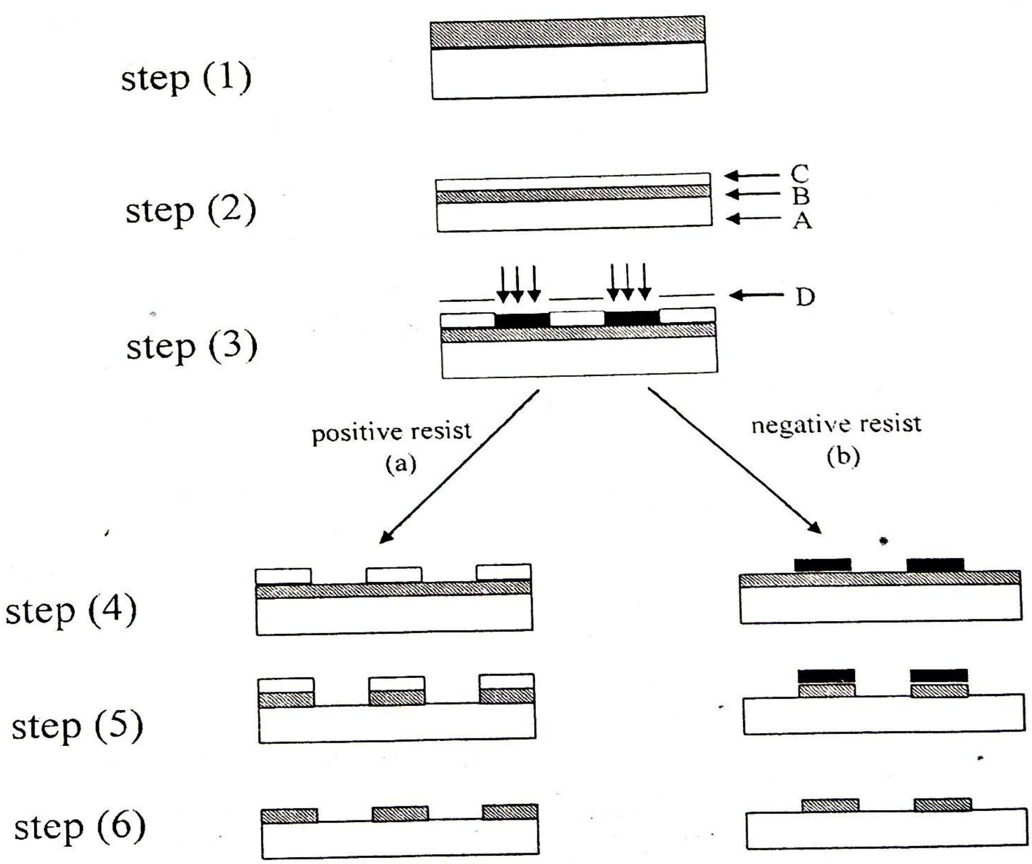


FIGURE 16.1 The steps in the lithographic process. (1) Form dielectric layer, (2) coat with polymer resist, (3) expose to electromagnetic radiation, (4) develop pattern, (5) etch, (6) strip resist. A: The substrate (silicon, etc.), B: thin dielectric layer (e.g., SiO_2), C: polymer resist layer, and D: mask.