POSITIVE PHOTORESISTS CONTAINING PREFORMED POLYGLUTARIMIDE POLYMER

FIELD OF THE INVENTION

This invention relates to a positive photoresist system, and more particularly, to a positive photoresist system possessing a high degree of thermal stability, resolution over a wide range of exposing radiation wavelengths, and other properties useful for forming an image on a substrate. The photoresist system of the invention is also useful as a planarizing layer in a multilayer resist system.

BACKGROUND OF THE INVENTION

Positive-acting photoresists, commonly referred to as postive photoresists, or positive resists, are useful for forming images on surfaces in lithographic and semiconductor processes. Typically, positive photoresist systems contain a mixture of a photoactive sensitizing compound or sensitizer, a coupler resin, and optionally minor amounts of additives, dissolved in a single solvent or mixed solvent system. The photoresist system must be capable of being applied as a thin adherent layer or film, having a thickness of about 0.5 to about 3 micrometers, on the surface of a base material such as a silicon wafer or printed circuit board. After the film or resist layer is dried to remove the solvent, a photomask with opaque image areas, delineating the desired pattern or circuitry to be imaged onto the surface, is brought into close contact with the photoresist film. When the photomask is in position, the positive photoresist layer, not covered or blocked by the photomask, is exposed to a source of energy, such as ultraviolet, visible light, X-ray, electron beam or other electromagnetic radiation. The positive photoresist layer exposed to the radiation undergoes a chemical change which renders the exposed layer more soluble in a developing solution, such as an aqueous base, than the unexposed portion of the photoresist layer.

The coupler resin in a positive resist system is selected because of its solubility in a solvent, as well as in a developing solution, and on its ability to form an adherent film on a substrate. The solubility of the coupler resin in a developing solution is inhibited by the presence of the photoactive sensitizer compound. The sensitizer, in the areas not exposed to the radiation, is not soluble in the developing solution. The sensitizer compound, however, undergoes a chemical reaction upon absorption of the exposing radiation. The exposed sensitizer is at least partially converted to a compound which is soluble in the developing solution. Based on the difference in the dissolution rate of the unexposed film and the exposed film, the developing solution preferentially dissolves the exposed areas of the photoresist film. Following this developing step, the substrate has been imaged and is ready for circuitry to be placed on the surface in the imaged or developed areas. Subsequently, the unexposed photoresist is stripped from the surface by a stripping solution.

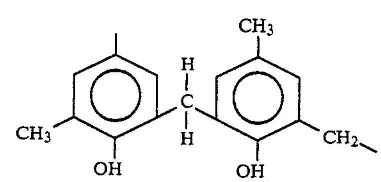
Therefore, the coupler resin, sensitizer, solvent, developing solution and stripping solution are selected based on their compatibility and effectiveness as components in an efficient and accurate imaging process.

The coupler resin serves to provide adhesion of the coating to the surface, to fortify the coating for better chemical resistance, to reduce the tendency for the sensitizer to precipitate from the coating, to increase the viscosity and coating characteristics of the photoresist film, and to reduce the cost of the photoresist sytem. Generally, for aqueous base developed systems, the resins are not photosensitive and are not extremely hydrophobic, but dissolve slowly in aqueous base and are resistant to acids. If the resin dissolves too rapidly in aqueous alkaline solutions, however, the unexposed areas of the film can be leached away during developing and no useful image can be formed. The resin therefore must be as hydrophobic as possible and yet remain capable of being dissolved in aqueous alkaline developing solutions. Resins containing phenols, ethers formed from phenols, and aromatic amines have been used in positive photoresist systems containing photoactive sensitizing compounds.

A typical conventional coupler resin is a low molecular weight, on the order of about 3000 to about 5000 weight average molecular weight, condensation polymer of a phenol, such as cresol, and formaldehyde. Typical sensitizers used with such coupler resins are derivatives of compounds variously called diazo oxides or orthoquinone diazides prepared in either naphthalene or benzene forms. The selection of a suitable non-reacting solvent for the resin and sensitizer is critical in the formation of a uniform coating or film and in the prevention of the sensitizer from crystallizing and precipitating from the system.

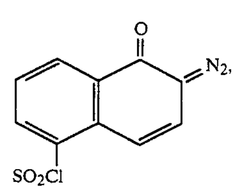
DESCRIPTION OF THE PRIOR ART

The background, types and operation of conventional photoresists are described in W. S. DeForest, *Photoresist Materials and Processes*, McGraw-Hill, 1975. In order to understand the factors which are important in formulating and evaluating a positive photoresist system, the advantages and disadvantages of a typical positive photoresist sytem, containing a commercial coupler resin, will be described. Novolak is a generic term used to identify low molecular weight condensation polymers of phenols, such as cresol, and formaldehyde having repeating units of the following chemical structure:



On a solids basis, a conventional photoresist system contains about 75 percent by weight of the solids, a novolak coupler resin and about 25 percent of the solids of a sensitizer dissolved in a solvent system.

A typical positive acting sensitizer, useful with coupler resins such as novolak, is a naphthalene diazoketone or napthoquinone diazide formed by reacting napthoquinone-1,2-diazide-5-sulfochloride, having the following chemical structure:



(formula R)