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Photolithography: Preparation Of Microscale Polymer Profile: A Review On Recent Development And Prospective

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***Abstract:** The concepts behind microchip construction via photolithography are demonstrated by a simple laboratory experiment by using polymer chemistry. In this experiment, a glass microscope slide acts as the microchip. WE can pattern this "microchip" by layering negative photoresist on the slide using a solution containing monomer, crosslinker, photoinitiator, and dye. We then cover the photoresist with a photomask, which is the negative of a computer-generated image or text printed on transparency film, and illuminate it with UV light. The photoresist in the exposed area polymerizes into a polymer network with a shape dictated by the photomask. The versatility of this technique is exemplified by allowing each strip to fabricate virtually any shape imaginable, including his or her profile. This experiment allows us to visualize the concepts behind the lithography of microchip construction using analogous polymerization techniques. It promotes understanding of photolithography, crosslinking density, and the process of photopolymerization, while demonstrating the power of rapid prototyping used to fabricate microscale devices.*

***Keywords:** controlled indexing, Position sensitive particle detectors, Prototypes, Silicon radiation detectors, Fabrication of the sensor*

I. INTRODUCTION

Photolithography, also termed optical lithography or UV lithography, is a process used in micro fabrication to pattern parts of a thin film or the bulk of a substrate. It uses light to transfer a geometric pattern from a photo mask to a light-sensitive chemical "photo resist", or simply "resist," on the substrate. A series of chemical treatments then either engraves the exposure pattern into, or enables deposition of a new material in the desired pattern upon, the material underneath the photo resist. For example, in complex integrated circuits, a modern CMOS wafer will go through the photolithographic cycle up to 50 times. *Photolithography* shares some fundamental principles with photography in that the pattern in the etching resist is created by exposing it to light, either directly (without using a mask) or with a projected image using an optical mask. This procedure is comparable to a high precision version of the method used to make printed circuit boards. Subsequent stages in the process have more in common with etching than with lithographic printing. It is used because it can create extremely small patterns (down to a few tens of nanometers in size), it affords exact control over the shape and size of the objects it creates, and because it can create patterns over an entire surface cost-effectively. Its main disadvantages are that it requires a flat substrate to start with, it is not very effective at creating shapes that are not flat, and it can require extremely clean operating conditions.

II. PHOTOLITHOGRAPHY

Lithography is done by standard techniques to expose the region for micromachining.

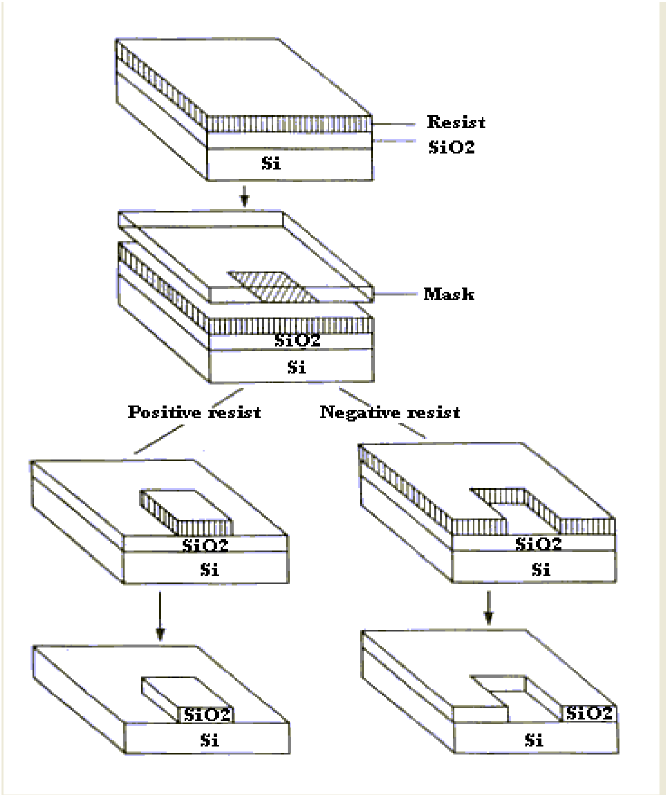

Figure 1: Photolithography of Silicon Sensor

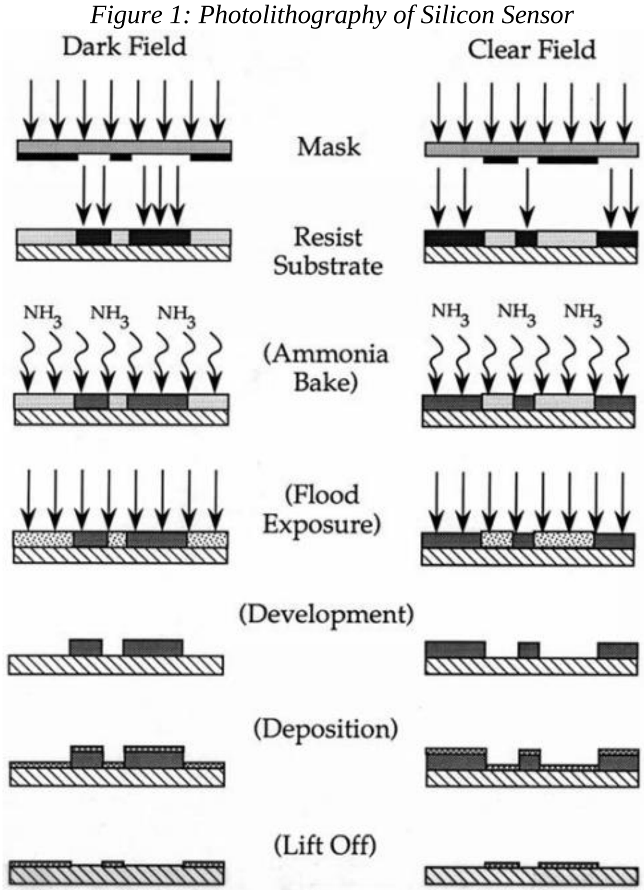

Figure 2: Mask Formation of Silicon Sensor

Microcircuit fabrication requires the precise positioning of a number of appropriately doped regions in a slide of semiconductor, followed by one or more interconnection patterns. These regions include a variety of implants and windows in protective cover layers through which connections can be made to the bonding pads. A sequence of steps is required, together with a specific layout pattern, for each of these regions lithographic processes are used to perform these operations and are carried out in succession during circuit fabrication. The major steps in lithography are:

Fabrication of masks (or pattern generation); and Lithography is the technique of transferring the pattern on the mask to a layer of radiation sensitive material (resist) which, in turn, is used to transfer the pattern to the films or substrates through etching I processes. The radiation used may be optical, X-ray, electron beam (e-beam), or ion beam. Each technique involves a specialized technology.

Transfer of the pattern to the wafer. In Photolithography, a film of the photo resist is first applied to the substrate. Radiation is shone through a transparent musk plate, on which has been imprinted a copy of desired pattern in an opaque material. The resulting image is focused on to the resist-coated substrate, producing areas of light and shadow corresponding to the image on the mask plate. In those regions where light was transmitted through the plate, the resist solubility is altered by a photochemical reaction. Shadowed areas remain unaffected in solubility. This step is termed exposure. Following exposure, the substrate is washed with a solvent that preferentially removes the resist areas of higher solubility. This step is called development. Depending on the type of the resist, the washed-away may be either the illuminated or shadowed regions of the coating. A resist that loses solubility when illuminated form a negative image of the plate and is called a negative resist. If exposure increases resist solubility resist is washed away in the areas corresponding to the transparent zones of the mask plate. The resist image is identical to the opaque image on the plate, and the pattern is a photographic positive. Therefore, the resist is called positive resist. After development, the substrate bearing the patterned resist, is exposed to an echant. The enchant removes those portions of the substrate unprotected by the resist while the covered areas remain unetched. Finally, the resist coating is removed and discarded, leaving a duplicate of the mask plate pattern etched into a substrate film.

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The Working:

STEP 1: The cleaned wafer is put on the top of the spinner hold by vacuum.

STEP 2: The negative photo resist is spread on the center of the wafer and the spinner is switched at a speed of 400r.p.m. for 25 sec. for uniform distribution.

STEP 3: The wafer is put inside the furnace for pre-bake at a temperature of 90°C for 20min.

STEP 4: The wafer is then put inside the furnace at 120°C for 20min.We used special photo resist, which did need hard bake.

STEP 5: The wafer is then put under the microscope and the vacuum pump is put in the holder of the mask-aligner.

STEP 6: The wafer is then loaded and the lid is closed and properly aligned by watching under the microscope thereafter.

STEP 7: The U-V source is then put in proper place and the wafer is then exposed for 5 sec. to U-V ray.

STEP 8: The film over the wafer is then developed and rinsed in Acetone to remove photo resist.

Lithography is used to transfer a pattern from a photomask to the surface of the wafer. For example the gate area of a MOS transistor is defined by a specific pattern. The pattern information is recorded on a layer of photoresist which is applied on the top of the wafer. The photoresist changes its physical properties when exposed to light (often ultraviolet) or another source of illumination (e.g. X-ray). The photoresist is either developed by (wet or dry) etching or by conversion to volatile compounds through the exposure itself. The pattern defined by the mask is either removed or remained after development, depending if the type of resist is positive or negative. For example the developed photoresist can act as an etching mask for the underlying layers.

A. ETCHING

Etching is used to remove material selectively in order to create patterns. The pattern is defined by the etching mask, because the parts of the material, which should remain, are protected by the mask. The unmasked material can be removed either by wet (chemical) or dry (physical) etching. Wet etching is strongly isotropic which limits its application and the etching time can be controlled difficultly. Because of the so-called under-etch effect, wet etching is not suited to transfer patterns with sub-micron feature size. However, wet etching has a high selectivity (the etch rate strongly depends on the material) and it does not damage the material. On the other side dry etching is highly anisotropic but less selective. But it is more capable for transfering small structures.

B. DEPOSITION

A multitude of layers of different materials have to be deposited during the IC fabrication process. The two most important deposition methods are the physical vapor deposition (PVD) and the chemical vapor deposition (CVD). During PVD accelerated gas ions sputter particles from a sputter target in a low pressure plasma chamber. The principle of CVD is a chemical reaction of a gas mixture on the substrate surface at high temperatures. The need of high temperatures is the most restricting factor for applying CVD. This problem can be avoided with plasma enhanced chemical vapor deposition (PECVD), where the chemical reaction is enhanced with radio frequencies instead of high temperatures. An important aspect for this technique is the uniformity of the deposited material, especially the layer thickness. CVD has a better uniformity than PVD.

C. CHEMICAL MECHANICAL PLANARIZATION

Processes like etching, deposition, or oxidation, which modify the topography of the wafer surface lead to a non-planar surface. Chemical mechanical planarization (CMP) is used to plane the wafer surface with the help of a chemical slurry. First, a planar surface is necessary for lithography due to a correct pattern transfer. Furthermore, CMP enables indirect pattering, because the material removal always starts on the highest areas of the wafer surface. This means that at defined lower lying regions like a trench the material can be left. Together with the deposition of non-planar layers, CMP is an effective method to build up IC structures.

D. OXIDATION

Oxidation is a process which converts silicon on the wafer into silicon dioxide. The chemical reaction of silicon and oxygen already starts at room temperature but stops after a very thin native oxide film. For an effective oxidation rate the wafer must be settled to a furnace with oxygen or water vapor at elevated temperatures. Silicon dioxide layers are used as high-quality insulators or masks for ion implantation. The ability of silicon to form high quality silicon dioxide is an important reason, why silicon is still the dominating material in ICfabrication.

E. ION IMPLANTATION

Ion implantation is the dominant technique to introduce dopant impurities into crystalline silicon. This is performed with an electric field which accelerates the ionized atoms or molecules so that these particles penetrate into the target material until they come to rest because of interactions with the silicon atoms. Ion implantation is able to control exactly the distribution and dose of the dopants in silicon, because the penetration depth depends on the kinetic energy of the ions which is proportional to the electric field. The dopant dose can be controlled by varying the ion source. Unfortunately, after ion implantation the crystal structure is damaged which implies worse electrical properties. Another problem is that the implanted dopants are electrically inactive, because they are situated on interstitial sites. Therefore after ion implantation a thermal process step is necessary which repairs the crystal damage and activates the dopants.

F. DIFFUSION

Diffusion is the movement of impurity atoms in a semiconductor material at high temperatures. The driving force of diffusion is the concentration gradient. There is a wide range of diffusivities for the various dopant species, which depend on how easy the respective dopant impurity can move through the material. Diffusion is applied to anneal the crystal defects after ion implantation or to introduce dopant atoms into silicon from a chemical vapor source. In the last case the diffusion time and temperature determine the depth of dopant penetration. Diffusion is used to form the source, drain, and channel regions in a MOS transistor. But diffusion can also be an unwanted parasitic effect, because it takes place during all high temperature process steps.

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