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Anisotropic Etching of Silicon A Review on Recent Development and Prospective

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Abstract:
One common MEMS (Micro-Electro Mechanical Systems) fabrication technique is the anisotropic etching of crystalline silicon, where etch rate is a function of orientation. The anisotropic etching of silicon is ubiquitous process in micromachining. Complex *Microsystems* can be generated using the anisotropic properties of single crystal silicon in an orientation dependent dissolution reaction. V-groove structures for example, useful for the passive alignment of optoelectronic devices are easily fabricated using an anisotropic etchant like KOH or tetramethylammonium hydroxide.

Keywords: CONTROLLED INDEXING, position sensitive particle detectors, prototypes, silicon radiation detectors,

1. INTRODUCTION

Porous silicon is a derivative of bulk crystalline silicon. Porous silicon consists of numerous pores and inter-connected silicon crystallites resembling sponge-like / Fur-tree-like structure , the pores ranging from < 2nm to a few microns. There are different techniques for preparation of porous silicon. Two methods have mainly been applied for the preparation of PS: (i) anodic etching in HF and (ii) chemical (stain) etching. Our studies on PS have primarily been focused on PS prepared by anodic etching. In some cases, stain etching has been used subsequent to PS formation by anodic etching in order to increase the porosity of the PS layers. Many of the physical properties e.g. electrical and optical properties of porous silicon differ significantly from those of crystalline silicon and these are closely related to the Porous silicon nanostructure which in turn depends on various parameters like formation current density, HF concentration, c-Si surface morphology, doping type and level of c-Si etc.

Type test of the silicon wafer

We measured the type of the silicon wafer by the method of Hot Probe test. In this method, we warmed one terminal of the probe and placed the terminals on the wafer. If the wafer is of P- type, then a negative voltage will be displayed in the meter and if the wafer is of N -type then a positive voltage will be displayed in the meter. In our case the reading in the meter was negative. Hence we came to conclusion that the wafer is of P type.

2. FABRICATION STEPS:

2.1. Cleaning

Step1: Sample + Acetone. Then boil for 3min. And then treat in Ultrasonic cleaner for 3min. to remove dust particles, oil and greese.
Step2: Dip in Methanol to avoid Oxidation of the sample.
Step3: (1:1) conc. H_2SO_4 + H_20_2. Wait till the completion of reaction. Then clean in DI-water to remove the oxide of the sample.
Step4: Dip in 10% HF solution. Then clean in DI-water to remove the oxide of the sample.
Step5: Treat the sample with Std. Cleaning-1 [H_20 (5):H_20_2(1):NH_40H(1)] at a temp- of 70°C for 10min. And then pass through cold water to remove the residual organic material.
Step6: Treat the sample with Std. Cleaning-2 [H_2O (6): H_2O_2(1):HCI(1)} at 700C for 10min. Then pass through DI-water to remove the residual organic material and dry with N_2.

2. 2 Oxidation

Oxidation is a fundamental process in all silicon device fabrication. Oxidation of silicon wafers is used for: (i) passivation of the silicon surface (i.e., the formation of a chemically and electronically stable surface), (ii) masking of diffusion and ion implantation, (iii) dielectric films, and (iv) an interface layer between the substrate and other materials, such as in chemical and biosensors. Silicon, when exposed to the air at room temperature, will grow a native oxide (about 20 A thick). Thicker oxides can be grown at elevated temperatures in dry or wet oxygen environments. At a given temperature, the relationship between the thickness of oxide and time is parabolic. The rate of growth is also affected by the partial pressure of the oxygen atmosphere and the crystal orientation. The ability to grow a chemically stable protective layer of silicon dioxide SiO_2 on a silicon wafer makes silicon the most widely used semiconductor substrate. The silicon dioxide layer is both an insulating layer on the silicon surface and a preferential masking layer during the fabrication sequence. Semiconductors can be oxidized by various methods. These include thermal oxidation, electrochemical oxidation and plasma A silicon dioxide layer is grown in an atmosphere containing either oxygen (O_2) or water vapour(H_20) at temperature in the range of 900°C to 1300°C . The following chemical reactions describe the thermal oxidation of silicon in oxygen or water vapour:

$$Si(solid) + 0_2(gas) \rightarrow SiO_2(solid)$$

$$Si(solid) + 2H_20(gas) \rightarrow SiO_2(solid) + 2H_2(gas)$$

The silicon - silicon dioxide interface interface moves into the silicon during the oxidation process. This creates a fresh

interface region, with surface contamination on the original silicon ending up on the oxide surface. The system used for Oxidation comprises of:
<a> Gas flow system consists of a nitrogen and oxygen cylinder at the back with the controls at the front to control the flow (Iit/min) of the gases. Then we have the bubbler with temperature controller.
<b> The Furnace consists of a quartz furnace separated from the body by quartz wool. The furnace also consists of a PID controller with 3-zone digital temperature controller along with other facilities like alarm setting.

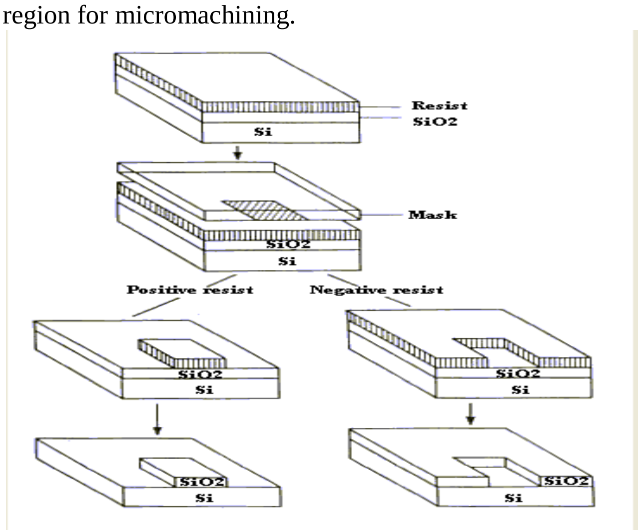
The Working:
Step1: The clean silicon wafer is mounted on a quartz stack with two butters.
Step2: The temperature of the furnace is set at 1000°C at all the 3 zones.
Step3: The Nitrogen cylinder is opened at $2Kg/cm^3$ and the flow is adjusted at 2lit/min for 5min.to purge the furnace.

For Dry Oxidation:
Step4: Then oxygen cylinder is opened at 2Kg/cm3 along with Nitrogen for 2min.
Step5: Now Nitrogen flow is stopped and oxygen at 1litlmin. is made to flow through the furnace for 5min.ln this way dry oxidation is done.
Step6: Reduce the oxygen flow and switch on the bubble.

For Wet Oxidation:
Step7: Now Oxygen is made to flow through the bubbler with temperature at 93°C and the flow is increased to 11itlmin slowly and kept it for 15min.
Step8: Again dry oxidation is done for 5min.
Step9: The oxidized wafer is brought out from the furnace and the color is observed to find the thickness. Also the wafer is observed under the microscope.

2.3 Photolithography

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



3.FABRICATION 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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