PLASMA RESIST IMAGE STABILIZATION TECHNIQUE (PRIST)

W. H-L. Ma

IBM Data Systems Division, East Fishkill
Hopewell Junction, New York 12533

ABSTRACT

PRIST, using a fluorocarbon plasma, effectively stabilizes the developed resist image in the production of integrated circuits. This plasma treatment, which is done at low power for a short time, allows the resist to be baked in excess of 210°C with no measurable change in dimensions. This phenomenon is attributed to the change in thermal properties of the resist surface effected by the active fluorine and fluorocarbon species generated in the plasma.

INTRODUCTION

A fluorocarbon plasma treatment allows wafers to be processed at high temperature without resist image and profile degradation.

Many integrated circuit fabrication operations, such as ion implantation, reactive ion etching, and lift-off metallization, frequently encounter high temperature during the process. Such extreme heat may be detrimental when a resist mask is used. Also, deformation of the developed resist can occur during post baking. Thus, the possible change in image size constrains the minimum dimension of the mask geometry.

EXPERIMENT

The plasma reactor used in this experiment is a low-pressure barrier type rf discharge system with a 20.3 cm (8") diameter and 33 cm (13") long quartz chamber. The chamber is evacuated by a roughing pump; the 13.56 MHz power is capacitively coupled to the chamber through a pair of metal electrodes.

The gases used are of fluorocarbon type, such as CF_4 and DE 100® (CF_4 + small amount of oxygen).

An AZ type positive resist is coated onto the Si wafer with or without the dielectric layers (oxide or nitride). After the image is developed on the resist, the wafers are briefly treated in a fluorocarbon plasma, followed by a 210°C post bake on a hot plate in an oven for 30 min.

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RESULTS AND DISCUSSION

Figures 1 and 2 show micrographs of a resist image after a 210°C post bake without and with PRIST, respectively. Without PRIST, the resist lines flowed and merged after the post bake, and the pattern is no longer recognizable. On the other hand, the PRIST-treated resist retained its integrity after the high temperature bake.

PRIST has a relatively wide process window. However, since fluorocarbon plasma also etches oxide, nitride, and silicon, it is advisable to minimize both rf power and treatment time. Both CF_4 and DE 100 produce satisfactory results. However, DE 100 is less desirable because a small amount of oxygen in CF_4 (i.e., DE 100) can increase etch rates of the substrate materials.

This technique can also be exercised in other plasma systems, such as reactive ion parallel plate reactor and inductively coupled barrier reactor.

We hypothesize that the fluorination of the resist surface is responsible for the stabilization of the resist image under a high processing temperature. The active fluorine and fluorocarbon species in the plasma react with the resist and fluorinates the surface. The treated surface has a higher softening temperature, and thus serves as a casting for the bulk resist, which maintains the developed resist image during the bake.

SUMMARY

PRIST is very effective in stabilizing the developed resist image. This technique, using fluorocarbon plasma, can prevent resist image deterioration even after a high temperature (210°C) post bake. This phenomenon is attributed to the change in the resist surface property due to chemical reactions which occur during the treatment.

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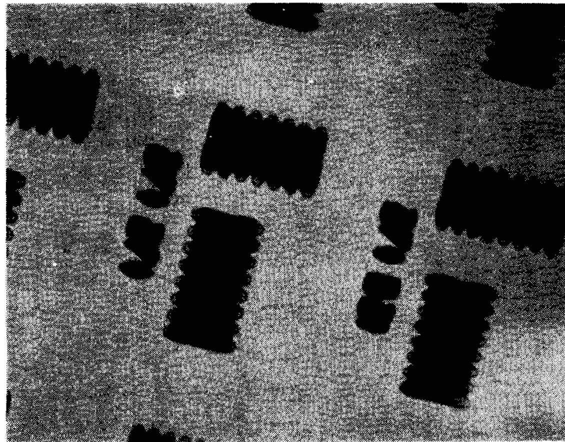

Fig. 1. Micrograph of a resist pattern after 210°C post bake without PRIST (320X)

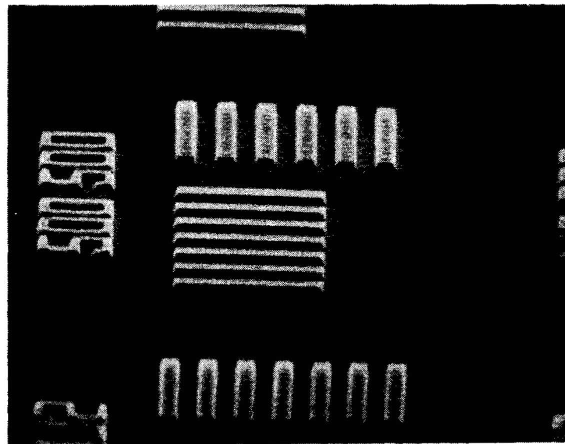

Fig. 2. Micrograph of a resist pattern after 210°C post bake with PRIST (800X)

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Fig. 1. Micrograph of a resist pa
210°C post bake without P

Fig. 2. Micrograph of a resist pa
210°C post bake with PRIS

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