BIRD'S HEAD PLANARIZATION FOR BIPOLAR DEVICES

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Abstract

An isotropic resist / oxide etchback process has been developed in order to reduce the height of the bird's head. This bird's head is formed during the field oxide growth in a fully recessed oxide isolation scheme, used to isolate bipolar devices. The so-called "bird's head planarization" technique results in improved step coverage in multimetallevel devices.

Introduction

An oxide isolation scheme allows higher performance than junction isolation, by the elimination of parasitic capacitances and allowing for an increase of the packing density. The LOCOS technology has been modified to make it applicable to bipolar devices [1 - 2]. A fully recessed LOCOS is formed by etching the epi-layer and the subsequent oxidation of this area. This provides deep isolation, although a bird's head appears in the oxide surrounding the nitride pad which can cause step coverage problems in multimetallevel processes. With the use of fully recessed oxide isolation, both the bird's beak and the head tend to increase.
Reducing the thickness of the pad oxide will decrease the bird's beak length and thicker nitride films result in suppression of the bird's beak and head formation. Reduction of the pad oxide and increase of the nitride thickness are both limited in respect of stress created between the silicon substrate and nitride film during field oxidation. This could lead to defects in the silicon [3].
The use of high pressure oxidation at low temperature also reduces stress. The reduced field oxidation time combined with the low temperature results in reduced lateral diffusion of the channel-stop implants, reduced updiffusion of the buried-collector and reduced lateral diffusion of the oxidant. The reduction of the lateral diffusion of the oxidant results in a decrease of the bird's beak length [4]. The non-planarity caused by this technique will need additional process steps to eliminate step coverage problems [5].

Oxide isolation and subsequent planarisation.

An oxidation mask consisting of 1000 Å thermal SiO_2 and 2000 Å LPCVD Si_3N_4 is produced. A photoresist mask is used to etch the nitride, oxide and the silicon epitaxial layer to a certain depth by anisotropic dry etch. Field oxidation in the etched area is performed by high pressure oxidation at low temperature. This technology results in a bird's head with a height of 7000 Å that curves the nitride of the oxidation mask. To eliminate subsequent step coverage problems due to this non-planarity, an isotropic etch is performed in a Matrix downstream etcher with SF_6 / O_2 / He chemistry to etch back the photoresist and oxide non-selectively. The configuration of this etchreactor results in a completely chemical etch. As the oxide etchrate is very sensitive to temperature the wafer is placed on a temperature controlled substrate holder.

Experimental and discussion.

Positive resist and HIPOX on <100> silicon are used for experiments.
After removal of the nitride oxidation mask, resist is spun over field topography.
These wafers are submitted to a two-step process.
Three statistical experiments are performed, the first one to optimize the etchback of the photoresist (step 1) , the second one to obtain optimal selectivity (step 2) and the third one with the two steps combined to evaluate the planarity of the surface.
The first step is to etch back the plain resist on topography wafers until the oxide becomes exposed. At that moment the recipe must be switched to a second step to etch back the resist and oxide non-selectively.
The first step is a low fluorine containing chemistry to maximize resist etchrate and improve the overall throughput. Fig. 1, Graph : Etchrate photoresist vs SF_6 % in O_2.
The second step has been optimized, first to maximize oxide etchrate mainly by using the highest possible temperature and second to optimize resist / oxide selectivity of 1 : 1. The selectivity can easily be controlled by the SF_6 / O_2 ratio. Fig. 2, Graph : Selectivity vs SF_6 / O_2. The adjustment of the selectivity by means of the SF_6 / O_2 ratio is limited to a maximum SF_6-flow relative to the O_2-flow. Too high a fluorine content causes resist hardening due to fluorination and subsequent variation of the selectivity during the process.
The processtime of step 1 and the resist to oxide selectivity in step 2 will define the resulting planarity.
At the end of step 1 a loading effect occurs at the moment that the oxide is exposed. The resist etchrate increases at the oxide interface and a non-planar surface is remaining. To eliminate this a very sensitive endpoint detection is needed. As the exposed area is very low at this point, timed mode is preferred in the first step.
A switch to the second step is made when a very thin resist film (1000 Å) still remains on top of the bird's head.
The best results are obtained with a resist to oxide selectivity between 1.1 and 1.2 in step 2 in order to provide optimal dispersion of the bird's head height after planarization. The results with different selectivities are shown in Fig. 3 and 4.
With the use of this two-step planarization process, a birds head of 7000 Å is reduced to a height of 3000 Å.
Fig. 5, Graph : Bird's head height and photoresist thickness vs processtime.

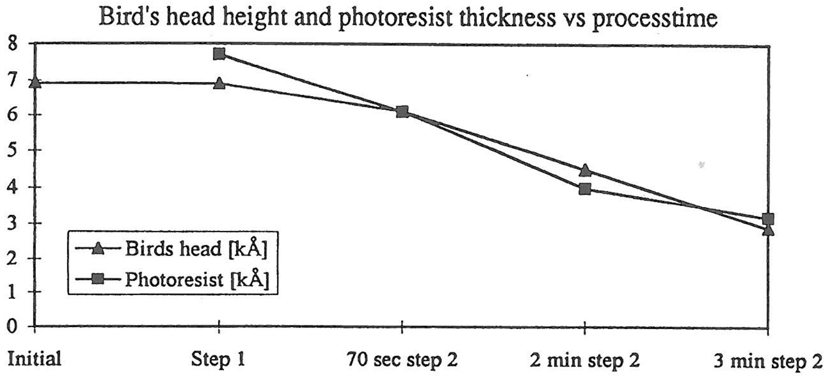

Fig. 5

After the planarization process, the remaining resist is stripped in a pure oxygen plasma at high temperature (250°C) in the Matrix stripper.
An in-situ resist strip in the Matrix etcher was considered in an attempt to simplify the process, but as a pure oxygen plasma can not be performed in this system [6] and the highly fluorinated resist is hard to remove, an SF6 / O2 plasma would be needed. This is too critical due to probable attack of the thin oxyde remaining in the active area.

Conclusion

The fully recessed oxide isolation technique results in a non-planarity caused by a bird's head formation surrounding the nitride oxidation mask. The dimensions of this head are determined by several parameters, such as pad oxide thickness, nitride thickness and field oxide thickness. The variation of these parameters is limited in respect of the necessity of adequate isolation and stress induced.
By application of this bird's head planarization technique after field oxide growth, the remaining non-planarity is reduced to a level that eliminates step coverage problems in subsequent steps.

Referencers

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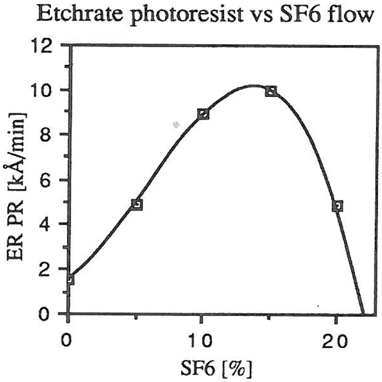

Fig.1

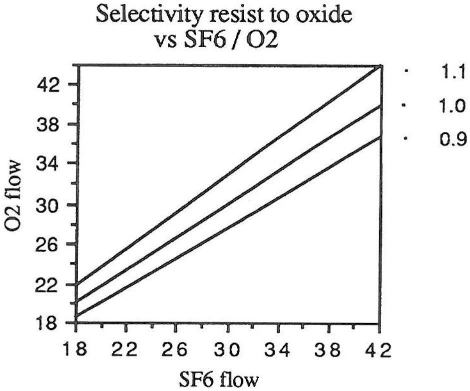

Fig. 2

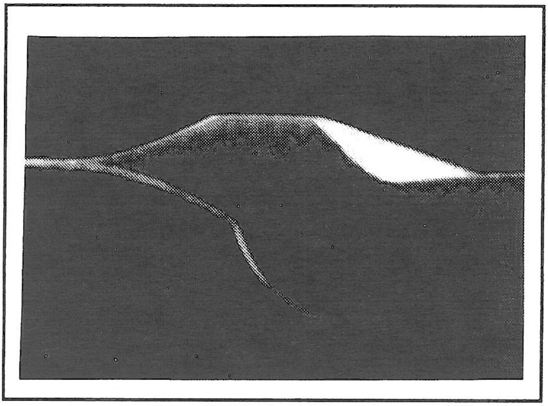

Fig. 3
Selectivity < 1

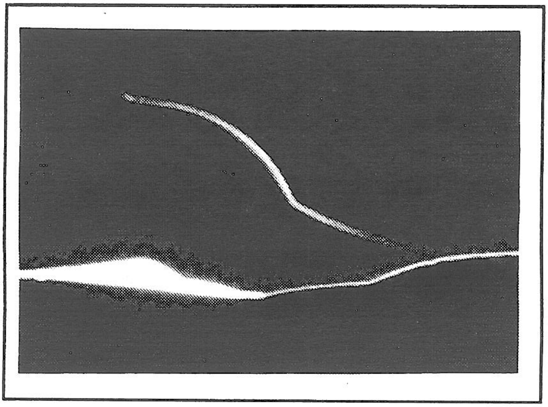

Fig. 4
Selectivity > 1