A New Self-Aligned Framed Mask Method for Selective Oxidation

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A selective oxidation process using a new structure mask has been developed for suppression of the bird's beak extent. The oxidation mask has a directly deposited Si$_3$N$_4$ frame around a conventional mask structure with pad SiO$_2$ and Si$_3$N$_4$. The framed mask is formed by self-aligned method.

Selective oxidation process steps in the framed mask method are shown in Figs. 1(a)-(d). First, a conventional mask consisting of a pad SiO$_2$ film 50-100 nm thick and a Si$_3$N$_4$ film 100-150 nm thick is photetched. Second, the conventional mask is covered with a second Si$_3$N$_4$ film by CVD method. Third, the frame is formed by reactive sputter etching of the second Si$_3$N$_4$ film. Reactive sputter etching realizes anisotropic etching and no lateral etching is recognized. Therefore, the second Si$_3$N$_4$ at the perimeter of the first Si$_3$N$_4$ film pattern is left when the second Si$_3$N$_4$ in the other region is fully etched off. Finally, selective oxidation is carried out in wet O$_2$ at 900-1100°C. The grown SiO$_2$ films are 600-800 nm thick.

SEM photographs of oxide structures formed by the conventional mask method and the framed method are shown in Figs. 2(a) and (b), respectively. The bird's beak in the conventional mask method is widely extended. On the other hand, in the framed mask method, it is suppressed by the Si$_3$N$_4$ frame and is shorter than the frame width. For 750 nm thick isolation oxide films, the bird's beak extent dependence on Si$_3$N$_4$ frame width is shown in Fig. 3. The bird's beak extent decreases as the frame width increases.

When a thick Si$_3$N$_4$ mask without pad SiO$_2$ is used, the bird's beak can be suppressed to a point as narrow as the framed mask. However, the thick Si$_3$N$_4$ mask method generates dislocations. Figure 4 shows SEM photographs of a cross section of a silicon wafer etched with Wright etchant after the selective oxidation. No dislocations are observed in the framed mask method. The presence of the pad SiO$_2$ under the Si$_3$N$_4$ film releases the stress and effectively suppresses dislocations.

Figure 5 shows the reverse current-voltage characteristics of a pn junction surrounded by isolation oxide. The reverse current in the framed mask method is as small as in the conventional mask method.

The framed mask method realizes fine width isolation and is applicable to high-density MOS LSIs.
Fig. 1 Selective oxidation process steps using the framed mask method.

Fig. 2 Oxide structures using conventional mask method (a) and framed mask method (b).

Fig. 3 Bird's beak extent dependence on Si$_3$N$_4$ frame width.

Fig. 4 SEM cross sectional view of a silicon wafer etched with Wright etchant after selective oxidation.

Fig. 5 Reverse I-V characteristics of pn junction.