

Lateral Solid Phase Epitaxy of Amorphous Si Films
onto Non-planar SiO₂ Patterns

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Lateral solid phase epitaxy(L-SPE) of amorphous Si(a-Si) films deposited on the Si substrate with SiO₂ patterns is a promising technique to realize silicon-on-insulator structures suitable for three-dimensional LSIs, since the process temperature of L-SPE is as low as 600°C. So far, several experimental results on L-SPE have been reported[1-6], and these results show that the planar structures, in which the surface step at the SiO₂ pattern edge is less than 40nm, are important to increase the L-SPE length (about 6 or 7 μm in undoped films[2,4] and about 24 μm in P-doped films[3]). However, in order to apply this technique to practical device structures, it will be necessary to grow Si films onto non-planar SiO₂ patterns. So, in this paper we investigate the L-SPE characteristics of undoped, B-doped and P-doped a-Si films onto the SiO₂ patterns formed by the LOCOS(local oxidation of silicon) method.

In the experiment, SiN films were deposited on n-type (100) Si wafers by plasma-enhanced chemical vapor deposition and patterned along <001> direction of the substrate. The wafers were then locally oxidized in wet O₂ atmosphere at 1025°C and the SiN masks were etched. Thicknesses of the SiO₂ films ranged from 60 to 470nm. The wafers with the non-planar SiO₂ patterns were chemically cleaned using RCA solution and mounted in an ultra-high vacuum chamber with base pressure of about 1x10⁻⁸Pa. After thermal cleaning at 800°C for 30min, Si films about 250nm thick were deposited on the wafers at a substrate temperature around 550°C by e-beam evaporation of undoped Si source. The vacuum pressure during deposition was less than 3x10⁻⁷Pa. To amorphize the deposited Si films, Si ions were implanted at room temperature at two energies of 150keV and 50keV with respective doses of 2x10¹⁵cm⁻² and 1x10¹⁵cm⁻². B and P ions were then implanted to investigate the impurity effect in L-SPE[3,5]. The implanted conditions were so chosen that the maximum impurity concentration of the B and P atoms in the films was nearly equal to 3x10²⁰cm⁻³ except the surface low concentration regions. Finally, the samples were furnace-annealed in N₂ atmosphere at 600°C and the growth areas were observed by a Nomarski optical microscope after Wright etching.

Figure 1 shows a cross-section SEM micrograph for a sample with a 290nm-thick LOCOS SiO₂ film. We can see that the transition region at the pattern edge is less than 1 μm and that the step height at the edge is about one half of the film thickness.

Figure 2 shows the variation of the L-SPE length along a <010> direction in the undoped and P-doped samples with the annealing time at 600°C. The thickness of the SiO₂ film was about 470nm in these samples. We can see from this figure that the L-SPE characteristics are essentially the same as those in the samples with planar SiO₂ patterns except that the initial acceleration of the L-SPE rate, which is known to occur in the L-SPE along the <010> direction due to the <110> facet formation[6], is not so pronounced in the LOCOS samples. That is, in the undoped film, the saturated growth rate (about 1.1x10⁻⁸cm/s) was almost the same as the rate in the planar samples[2,6], though the L-SPE length (about 4.5 μm) was a little shorter because of the small acceleration of the growth rate in the initial stage.

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In case of the P-doped sample, the L-SPE length was about 44 μm , which was much longer than that in the previous report[3]. However, we can say from another experiment using a planar structure that the enhancement of the L-SPE length is not due to the LOCOS structure, but it is probably due to improvement of the vacuum pressure during deposition of Si films. That is, it was found that the L-SPE length exceeded 50 μm in the planar samples prepared in the vacuum system described above and that the increase of the L-SPE length is not due to enhancement of the growth rate but due to delay of polycrystallization of the film. We can say from these results that the L-SPE characteristics of the P-doped LOCOS samples are almost the same as those of the planar samples except the initial acceleration stage. The L-SPE characteristics of the undoped and P-doped samples with thinner SiO₂ films were almost the same as those in Fig.2. In case of B-doped samples, the polycrystallization rate was much faster than that in the undoped samples, as can be predicted from the planar samples[5], and the L-SPE length in the LOCOS samples was about 6.5 μm .

We conclude from these results that the L-SPE characteristics along the $\langle 010 \rangle$ direction in the samples with non-planar SiO₂ patterns do not so differ from those in the samples with planar patterns except the initial acceleration stage, if the patterns are formed by the LOCOS method and if dense a-Si films prepared by ion implantation are used.

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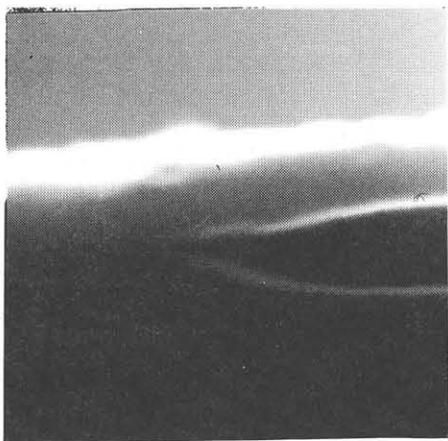


Fig.1 Cross-section SEM micrograph of a pattern edge of a LOCOS SiO₂ film.

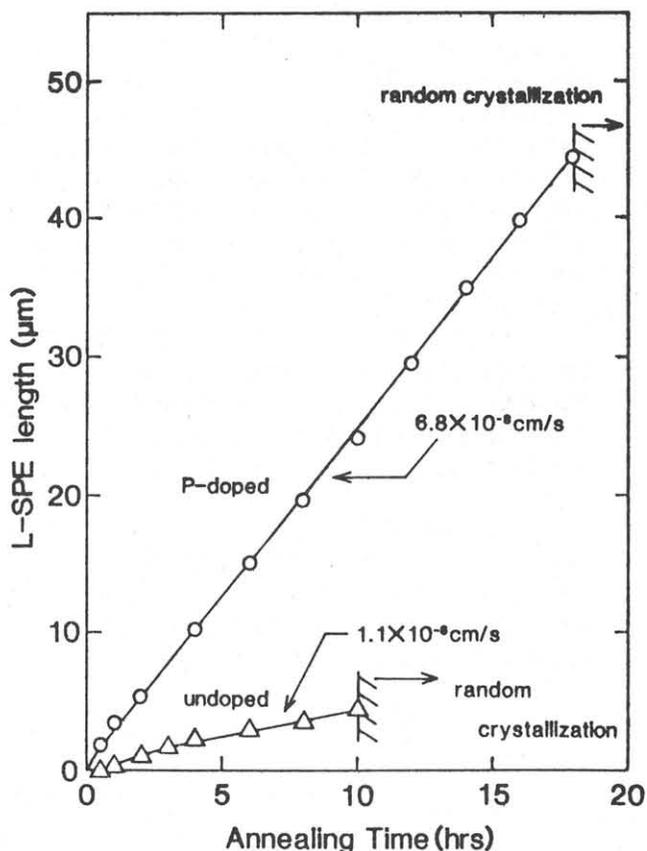


Fig.2 L-SPE length along a $\langle 010 \rangle$ direction in undoped and P-doped LOCOS samples as a function of annealing time at 600°C.