TOPICS

A New Technique for Detecting Oxygen Precipitates in Silicon Wafers Using Highly Selective Reactive Ion Etching

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高選択比異方性エッチングによるSi中微小酸素析出物検出法

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Oxygen precipitates in the active region of Si devices are detrimental to the electrical characteristics of the devices.[1)] To ensure the yield and reliability of Si devices, it is necessary to develop a process for reducing oxygen precipitates. To achieve this, a technique for detecting the precipitates is required. Although various techniques such as preferential etching, light scattering tomography (LST),[2)] and TEM have been used to detect oxygen precipitates, they cannot detect nanometer-sized, low-density precipitates. To detect such precipitates, we have recently proposed a new technique, which utilizes reactive ion etching (RIE) with a high Si/SiO_2 selectivity.[3)]

Figure 1(a) illustrates the detection principle of the RIE technique. When the RIE is performed on the surface of a wafer containing oxygen precipitates, needle-shaped Si cones are formed under the precipitates, because they are composed of SiO_x and are hardly etched. A typical SEM image of such Si cones is shown in Fig. 1(b).

To estimate the detectable size limit of the technique, the RIE was performed on wafers containing oxygen precipitates of different sizes, which were controlled by changing the annealing time of the wafers. **Figure 2** shows the dependence on annealing time of the density of Si cones formed after the RIE. The top axis shows the precipitate size calculated using the (annealing time)$^{1/2}$ law[4)] and the measured precipitate size of the 8-h-annealed wafer. The Si cone density abruptly increases at 2 h and almost reaches a constant value above 4 h. This indicates that precipitate size increases with annealing time, just beginning to exceed the detectable size limit at 2 h. Thus, the detectable size limit is estimated to be 4 nm from the precipitate size at 2 h.

Figure 3 shows the detectable size and density ranges of oxygen precipitates for four techniques. It is found that the RIE technique is useful over wider ranges of size and density than other techniques, and can detect small-sized, low-density precipitates that cannot be detected by other techniques.

Since Si cones formed after RIE have nearly the same shape, as observed in Fig. 1(b), the height of the cones, which depends on the depth position of the oxygen precipitates, can be calculated from the bottom diameter of the cones. Thus, the depth distribution of oxygen precipitate density can be easily obtained by measuring the bottom diameter of the cones. The depth resolution of this technique was about 0.3 um when the etching depth was 3um.[5)]

In addition, when the depth of the RIE is shallow, the morphology of oxygen precipitates can be revealed by TEM observation of the top of the Si cones, because the precipitates remain almost unchanged after the RIE. Using this method, we have succeeded in distinguishing platelet and octahedral oxygen precipitates.[5)]

In conclusion, the RIE technique is useful for distribution measurement and morphology observation of small-sized, low-density oxygen precipitates in Si wafers.

References

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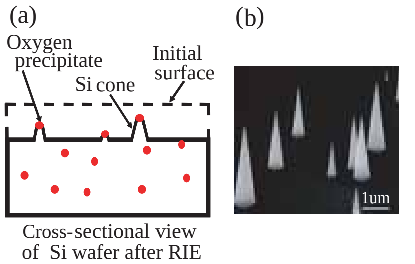

Fig. 1 Detection principle of RIE technique (a) and typical SEM image of Si cones after RIE (b).

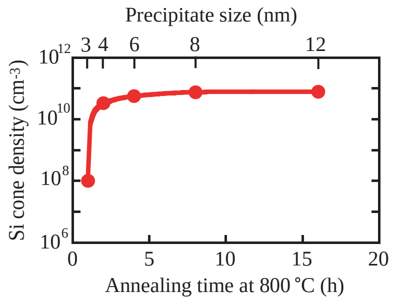

Fig. 2 Annealing time dependence of Si cone density.

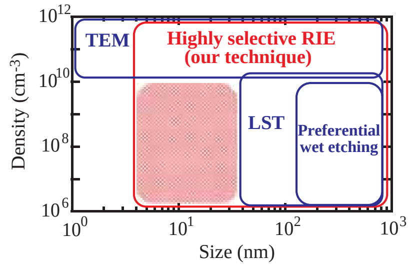

Fig. 3 Detectable size and density ranges of oxygen precipitates for four techniques.