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Direct Analysis for the Contamination in Contact and Via Holes Using Thermal Desorption Spectroscopy

Hidemitsu Aoki, Eiji Ikawa, Takamaro Kikkawa,
Yuden Teraoka*, and Iwao Nishiyama*

Microelectronics Research Labs, NEC Corp.
1129, Shimokuzawa, Sagamihara, Kanagawa 229, Japan
*Opto-electronics Research Labs, NEC Corp.
34, Miyukigaoka, Tsukuba, Ibaragi 305, Japan

A new analysis method for detecting contaminations in deep-submicron contact and via holes was developed by use of thermal desorption spectroscopy (TDS). The TDS analysis made possible to identify etching residues and contaminations such as $AlCH_3$ and AlF in deep sub-micron contact and via holes. It is also found that the AlF contamination in vias was strongly dependent on the degree of the over etching for the vias.

1. INTRODUCTION

As device dimensions are scaled down, aspect ratios for contact holes become greater and greater. Dry etching of contact holes and vias has become a key technology in the fabrication of very large scale-integrated circuits. When alkyl halide gases are used as etching gases for silicon oxide films, carbon-polymers are deposited on the surface, and when the through-holes are over-etched, carbon or fluorine compounds are deposited at the bottom of the holes. This severely degrades contact quality. In order to perform suitable treatment of holes[1] to reduce such degradation, it is important to analyze the amount and nature of the contaminations in these very small holes, which have such high aspect ratios. This is not possible, however, with conventional analysis methods, such as Micro Auger electron spectroscopy (Micro-AES) or secondary ion mass spectroscopy (SIMS), because of the resolution limit of the probe-beam of these analyses. The purpose of our study here is to develop a new method which can handle such analysis. While heating the substrate to produce thermal desorption of the contaminations, we were able to analyze them with great sensitivity by using a quadrupole mass spectrometer(QMS). This represents an important new application of thermal desorption spectroscopy[2) 3)].

2. EXPERIMENTS

Figure 1 shows a sample used for analysis. Chemical vapor deposited SiO_2 films with a thickness of 1.0μm were formed on 0.5μm thick Al films, which had been deposited on oxidized Si wafers, and etched with a conventional planar type reactive ion etcher employing CF_4 and CHF_3 mixture gases. The 0.6μm via holes were patterned using a 1.5μm thick photo resist mask. Table 1 gives etching conditions. Figure 2 shows post etching treatments. Total hole area was 25% of the sample surface. The samples without vias were fabricated by covering the SiO_2 surface with photo resists. Both samples with and without vias were etched and treated by the conditons shown in Table 1 and Figure 2. Figure 3 is a schematic drawing of the TDS apparatus used in this study. The QMS chamber wall was cooled to liquid nitrogen temperature, the desorption species emitted only from the sample surface could be detected without any contamination from the background. The TDS analysis was conducted in a temperature range from 100°C to 700°C. The heating rate was 100°C/min.

3. RESULTS AND DISCUSSION

Major desorption products were found to be AlC, $AlCH_3$, AlF and CF_3, as shown in Table 2. In this study, TDS spectra of $AlCH_3$ and AlF were investigated as representatives of corbon and flourine contaminations, respectively. Figure 4 shows the TDS spectra of $AlCH_3$ for samples without vias and with vias over-etched 40%. It is found that the TDS peak intensity for $AlCH_3$ at 470°C for samples with vias were 3 times larger than that for samples without vias, which indicated that the vias contained some amount of $AlCH_3$ contamination. Therefore, the TDS spectrum differences between the samples with vias and without vias were attributed to the etching contaminations and residues in the vias. The TDS spectra of AlF are shown in Figure 5. It is found

that the TDS peak intensity for $AlCH_3$ at 470°C for samples with vias were 3 times larger than that for samples without vias, which indicated that the vias contained some amount of $AlCH_3$ contamination. The similar results were obtained for AlF. From these results, it is found that the TDS could detect the contamination in the vias.

Figure 6 shows the TDS spectra of AlF for the sample with the via holes which were over etched 30%, 60%, and 100%. Broad AlF signals were observed from 500°C to 650°C at each level of over etching. As the over etching time increases, the intensity of the AlF peak at around 500°C drastically increases. The intensity for 100% over etched vias was about 200 times greater than that for 30%.

Consequently, the AlF contamination in the vias was dependent on the amount of over etching time.

4. CONCLUSION

We have developed a new method for analyzing the contamination in deep submicron-contact and via holes. The analysis by this method includes, the determination of the quantity of etching residues and other contaminations found in deep sub-micron contact and via holes, which are too small for ordinary analyses. By applying this method experimentally, it was shown that the AlF contamination by the etching was dependent on the degree of over etching. This method will help us to evaluate the effects of cleanning and other post-etching treatments of the deep sub-micron contact holes.

5. ACKNOWLEGMENTNT

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6. REFERENCES

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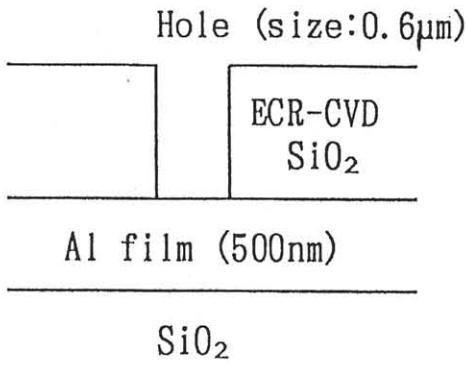

Figure 1 Cross-section of a sample for analysis

Table 1 Etching Condition

Apparatus	RIE
Etching Gas	CF_4
	CHF_3
Pressure	3pa
Over Etching	40%

Etching
↓
O_2 ashing (180sec)
↓
Rinsing by MEK (10min)
↓
Rinsing in water (10min)

Figure 2 Post-etching treatment

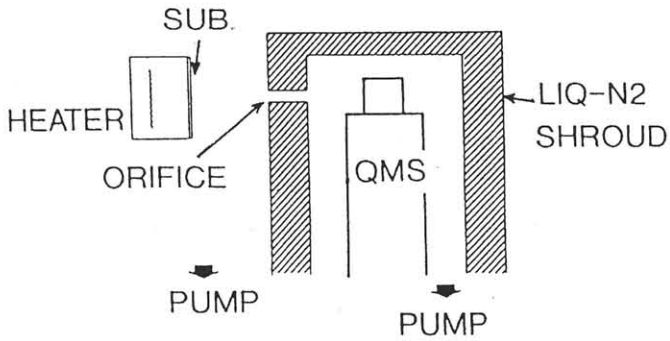

Figure 3 A schematic drawing of TDS apparatus

Table 2 The species list

Species	m/e
AlF	46
CF_2	50
CF_3	69
AlC	39
$AlCH_3$	42
$AlFCH_2$	61
$AlCHF_2$	78
$AlCF_3$	96

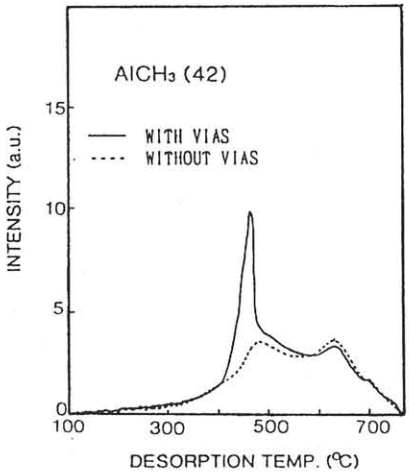

Figure 4 TDS spectra for $AlCH_3$

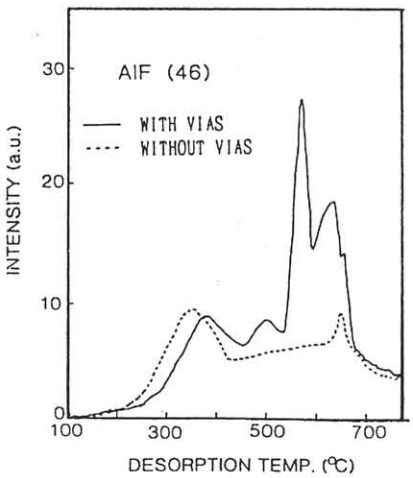

Figure 5 TDS spectra for AlF

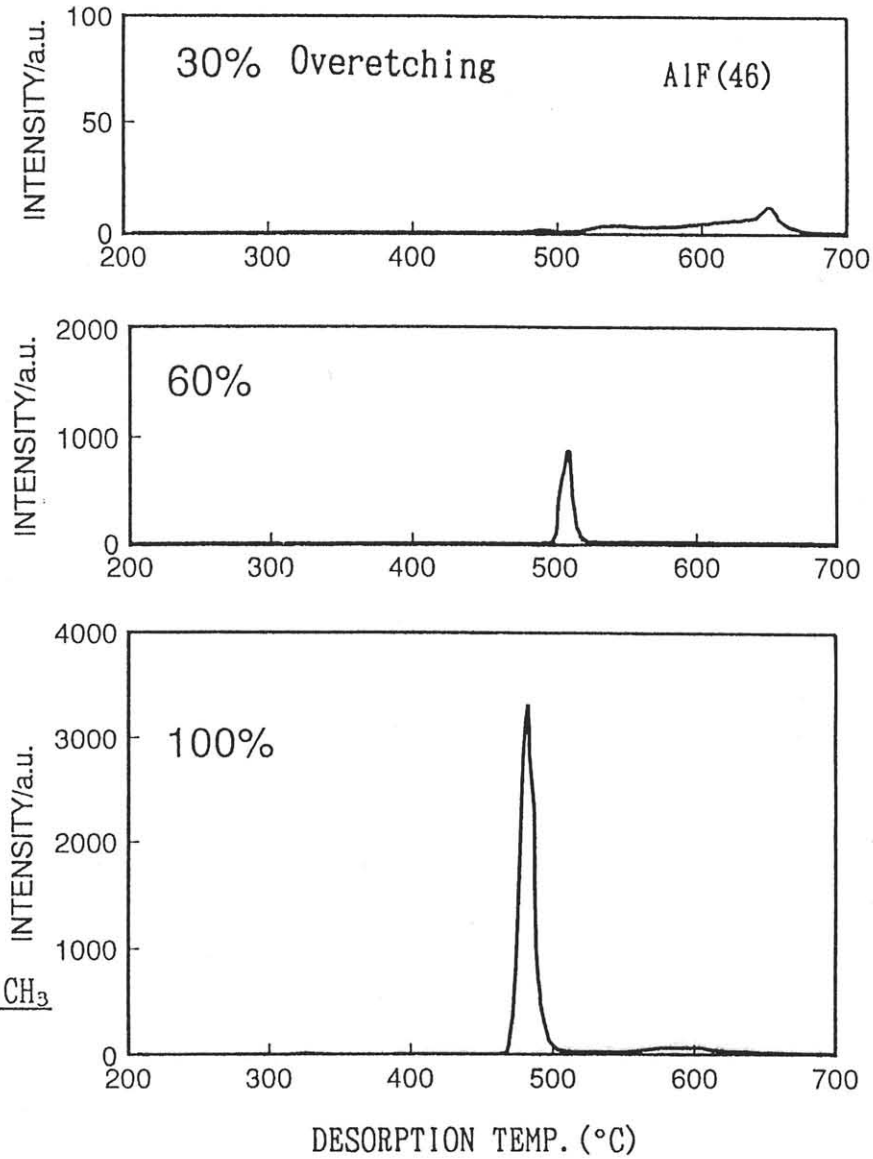

Figure 6 Dependence of AlF contamination on degree of overetching