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ロングDCアークによる難分解性ガスSF_6の分解機構
Decomposition Mechanism of SF_6 by Long DC Arc Plasma

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1. Introduction

Abatement processing with thermal plasmas has been implemented in industrial fields due to their advantages of high temperature, high chemical activity, and rapid treatment. Long DC arc has a long electrode gap distance, 300 mm. This configuration leads to sufficiently long residence time for decomposition of harmful target.

Sulfur hexafluoride, SF_6, is mainly used as the insulating medium in gas circuit breaker due to its thermally and chemically stable and as a dry etching gas in the semiconductor industry. SF_6 has a high global warming potential about 24,000, and is difficult to be decomposed. The purpose of this study is to decompose SF_6 by long DC arc and to investigate decomposition mechanism.

2. Experiment

The setup consists of a power supply, a plasma torch, and a scrubber. The arc current was 10 A. Nitrogen at 25 L/min was used as the plasma gas, while SF_6 was injected at 0.5 L/min. Steam (0, 0.75, 1.5 3.0 L/min) was introduced as the additive gas. This is because H and OH radicals inhibit recombination of SF_6 in the plasma region. Molar ratio of H/F was changed to 0.0, 0.5, 1.0 and 2.0.

The produced gases are analyzed by a gas chromatograph (GC) and a quadrupole mass spectrometer (QMS) to investigate the destruction and removal efficiency (DRE) and the composition of the produced gases.

3. Results and Discussion

Figure 1 shows the relationship between the H/F molar ratio and DRE. The DRE is 0% at H/F=0.0, because S and F radicals were recombined to SF_6 after thermal decomposition. The DRE value increased as the H/F ratio. The maximum DRE value was 97% at H/F=2.0. This is because F and H combine to form stable HF after decomposition of SF_6 and H_2O.

The gas component after SF_6 decomposition were analyzed by QMS. Obtained mass spectra were shown in **Fig. 2** SF_6 and SO_2F_2 peaks were decreased as H/F ratio was increased. SO_2F_2 was derived from oxidation of SF_x intermediates. Fluorine necessary for SF_x recombination was completely recovered to form HF. This resulted in undetectable SO_2F_2 at high H/F ratio.

4. Conclusion

SF_6 was successfully decomposed by long DC arc with steam addition. Long DC arc system is expected to play an active role in the semiconductor industry due to the ability to decompose alternative PFC gases completely.

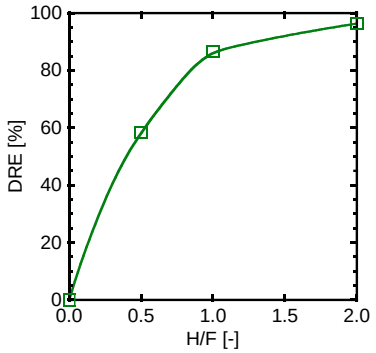

Fig. 1 Effect of H/F ratio on the DRE, SF_6 flow rate: 0.5 L/min, H_2O flow rate: 0.0, 0.75, 1.5, 3.0 L/min.

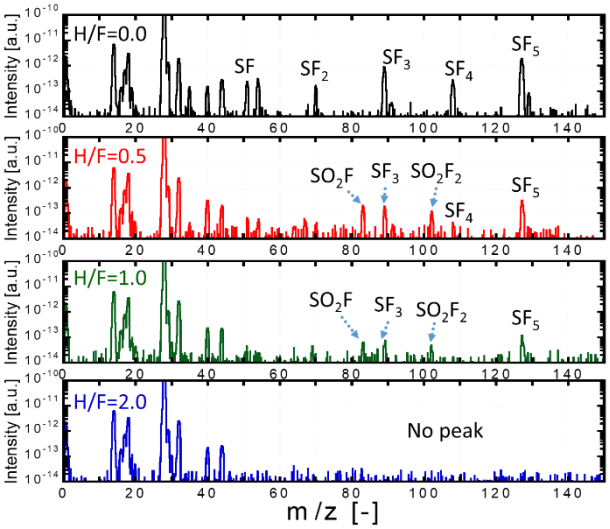

Fig. 2 Spectra of produced gas at various H/F ratio; H/F=0.0, 0.5, 1.0, 2.0.