REMOVAL OF POLYMER FOLLOWING REACTIVE ION ETCHING

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1. INTRODUCTION

During the Reactive Ion Etching (RIE) of oxide films on silicon a layer of polymer is formed on the silicon surface to assure adequate etch selectivity [1]. Prior to subsequent processing, notably prior to subsequent contact deposition, the polymer has to be removed.

In this experiment, two different polymer removal procedures followed by a gas-phase oxide etching are evaluated for potential inclusion into an integrated gas-phase cleaning process. These procedures involve UV/ozone and afterglow plasma generated oxidizing ambient with various gaseous additives [2]. An anhydrous HF etch was used to remove the thin oxide formed during the oxidizing procedure [3].

2. EXPERIMENTAL PROCEDURE

Starting wafers were prepared by reactive ion etching of a 200 nm thick layer of SiO_2 using CHF_3 at 75 mTorr and 400 watt power. These etch conditions resulted in a polymer layer approximately 95 nm thick. Polymer ashing was implemented using either an afterglow oxygen plasma or a UV/Ozone chemistry. The plasma was generated using microwave excitation at 2.46GHz with a gas mixture of argon and oxygen. Small amounts of NF_3 was also added to the input gas stream for some of the runs. The UV/Ozone process chamber has an ozone generator connected to the chamber and a high pressure xenon lamp that irradiates the reaction chamber through a sapphire window [4]. Gas flow of either oxygen or oxygen with methanol were used in the various runs. Both the afterglow plasma and the UV/ozone cleaning process leave a thin oxide on the sample surface. This oxide was removed using an anhydrous HF etch.

3. RESULTS AND DISCUSSION

Among issues of main interest in this study was the rate of polymer oxidation using various oxidizing chemistries generated in the tools capable of the subsequent in situ etching of the resulting ultra-thin oxide. Effective removal of the RIE deposited polymer is possible with either the remote oxygen plasma process or the UV/Ozone process.

The plasma system used in this investigation required a mixture of oxygen with argon to sustain a plasma. Figure 1 shows that as the amount of argon is increased in the input gas stream the polymer is removed at a faster rate. This may be due to the greater ionization of oxygen with increasing argon concentration. It may also be that more atomic oxygen is reaching the sample due to the higher total process gas flow. The addition of a small amount of NF_3 to the gas stream was

found to greatly accelerate the polymer removal rate. The presence of NF_3 in the plasma is most likely forming atomic fluorine, an aggressive oxidizing agent, which can enhances the oxidizing cleaning process [5]. The greater oxidizing potential resulting from the addition of NF_3 is also indicated by the relatively rapid thickening of the oxide after the polymer has been removed.

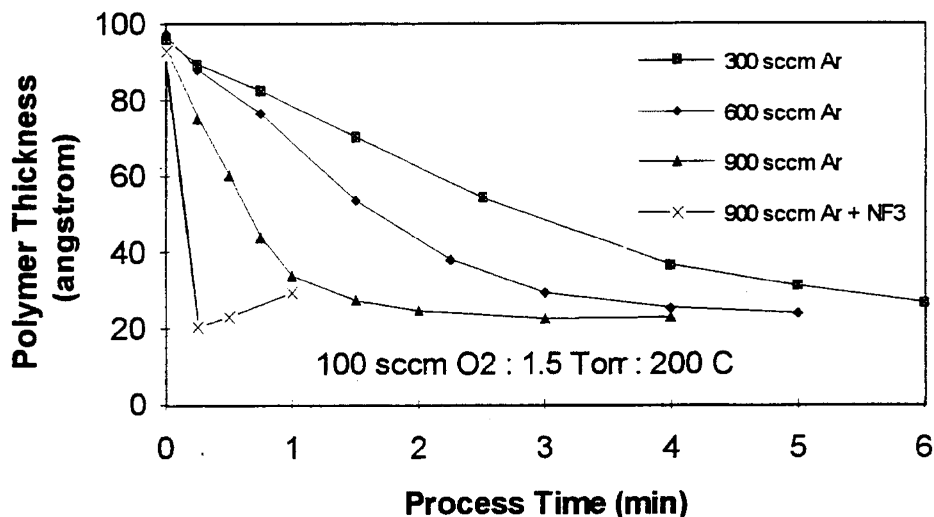

Figure 1 Effect of argon and NF_3 on the afterglow oxygen plasma removal of polymer.

Figure 2 shows that temperature is an important parameter in the polymer removal process using an afterglow plasma. As the temperature is increased the removal rate also increases. The results indicate that some thermal energy is required to activate the oxidation of the polymer in the presence of atomic oxygen. Pressure is also an factor that can affect the removal rate of the polymer. Our results show that the removal rate increases as the process pressure is decreased.

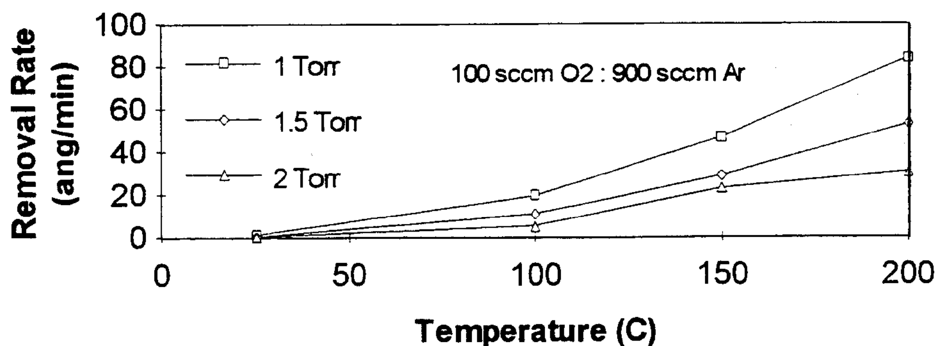

Figure 2 Effect of temperature and pressure on the removal rate of polymer in the afterglow oxygen plasma.

UV/ozone is another method that can be used to generate an oxidizing ambient capable of removing the polymer deposited by RIE [6]. Figure 3 shows that ozone produced from an electrical discharge combined with UV irradiation of the sample in the reaction chamber can effectively reduce the polymer thickness on

the sample surface. When methanol is added to the process chamber in the presence of ozone the removal of polymer is enhanced. It is likely that the addition of methanol to the process chamber is resulting in the formation of OH radicals which helps to oxidize the polymer [7]. The formation is of the OH radical is probably due to a reaction with some of the atomic oxygen since it was found that if a larger amount of methanol is added to the process the polymer removal rate starts to decrease, indicating the overall number of oxidizing species in the process ambient is decreasing.

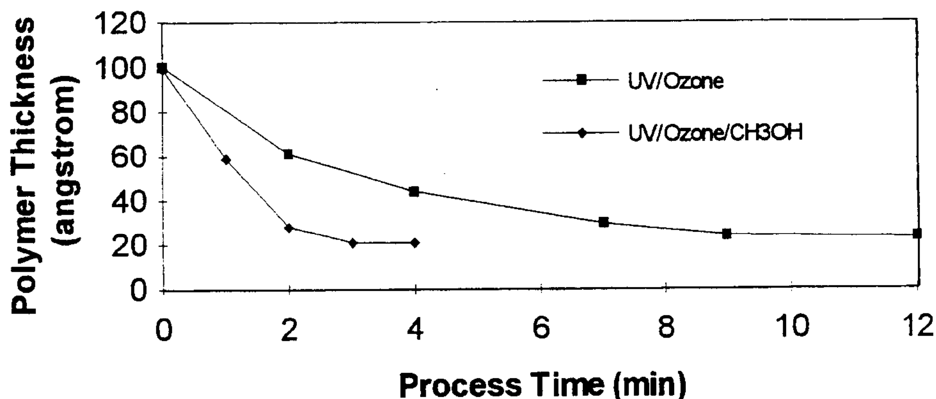

Figure 3 Polymer removal using UV/ozone and the enhancement of the removal by the addition of methanol.

Process temperature was also found to be an important parameter in the UV/ozone polymer removal process. Figure 4 shows that as the process temperature is increased from 75C to 150C the removal rate of the polymer is greatly increased.

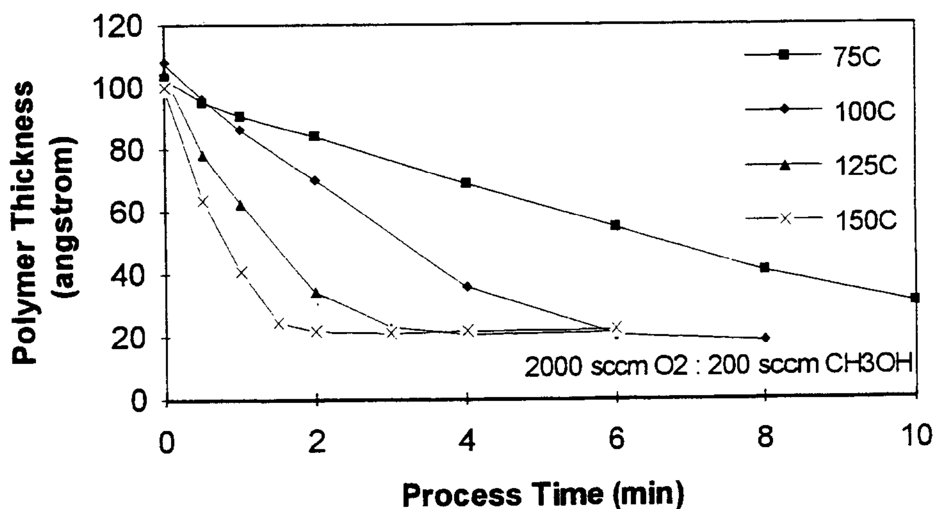

Figure 4 Temperature dependence of the UV/ozone polymer removal process.

4. SUMMARY

Afterglow oxygen plasma and UV/ozone were evaluated for feasibility of use as cleaning processes for post-RIE polymer removal. Both processes were found to effectively remove the polymer on the sample surface. The addition of a small amount of NF_3 to the afterglow plasma stream was found to greatly accelerate the removal of the polymer. Likewise the use of methanol in the UV/ozone process also showed an enhancement of the polymer removal process.

5. ACKNOWLEDGMENTS

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