The study of Low Pressure Fluorocarbon Plasma Polymerization with Tetrafluoromethane, Hexafluoroethane and Octafluorocyclobutane

Jia-Cih Jhuang[1] , Chun Huang[1]
[1]Department of Chemical Engineering & Materials Science, Yuan Ze University, 135 Yuan-Tung Road, Chung-Li 32003, Taiwan
chunhuang@saturn.yzu.edu.tw
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Abstract: The nano-scale fluorocarbon films were deposited of fluorocarbon monomers by radio frequency low pressure plasma observed using tetrafluoride, hexafluoroethane and octafluorocyclobutane, low surface energy was prepared by changing the plasma pressure, power and duty cycle. The films was characterized and investigated by thin film analyser, scanning electron microscope, and fourier transform infrared spectrometry.

Keywords: tetrafluoromethane, hexafluoroethane, octafluorocyclobutane, low pressure plasma, duty cycle.

1.Introduction

Plasma polymerization was the use of plasma chemical vapor deposition (PECVD)[1], the film adhesion and coverage of the process were well, and it was suitable for a variety of materials, and wouldn't be affected by whether the substrate was due to the influence of the conductor, especially the low sedimentary temperature, it can not only change the physical and chemical properties of the substrate itself, but also retain the properties of the substrate to a large extent.

Plasma polymerization had been widely used in the industry. Because it is difficult to maintain the complete structure of monomers under UV light irradiation and plasma ion bombardment, pulsed plasma assisted chemical vapor deposition has been developed. The biggest advantage of this method is to reduce the process temperature and ion bombardment to preserve the original characteristics and structure of the monomer[2]. The method was in the plasma matching circuit, the pulse system can control the on/off of the plasma output, and each on+off time is called an duty cycle. In 2009, Yanhong.Liu et al.[3] deposited C_4F_8 to prepare a diamond film on the surface, and found that the cross-linking of the film produced in a low-pressure environment was higher than that in a high-pressure environment. The fluorocarbon film was hydrophobic and biocompatible, and was easily dissociated into Free radicals or ions successfully prepared thin films with low dielectric constant.

2.Experiment

The monomers used for low-pressure plasma polymerization of fluorocarbon film was tetrafluoromethane (CF_4,99.97%), hexafluoroethane (C_2F_6, 99.98%), and octafluorocyclobutane (C_4F_8,99.97%). The plasma reactor system used a bell jar-type reactor.

The reactor was connected with a 13.56MHz RF power supply. The power supply had the pulsed plasma mode that can be used to reduce the damage of ion bombardment and maintain the original characteristics and structure of the monomer . Fix the flow rate of fluorocarbon monomer at 6sccm, change the system pressure from 200-1000mTorr, change the plasma power from 20-80W, and change the duty cycle by 10-100%.

3.Results and discussion

Use thin film analyser to measure the thickness of the fluorocarbon film, and transmited it back through light reflection, which will not damage the surface of the film. The trend of the three gases was that when the pressure increased, the film thickness will decrease. The monomer was limited by the mean free path when the pressure was high, the monomer was difficult to be dissociated and can not be deposited on the substrate. Therefore, the film thickness will decrease when the pressure increased. When the plasma power increased, the thickness of the film also increased. The plasma power increased the energy provided also increased and more monomers can be dissociated to form a film. It can also be seen from the trend that when the power increased, the film thickness of tetrafluoromethane decreased. Because the fluorine-to-carbon ratio of tetrafluoromethane was greater than 2, and the fluorine was more than carbon, which was more inclined to the etching reaction and was difficult to deposit.Both hexafluoroethane and octafluorocyclobutane increased the thickness of the film when the plasma power increased.When the duty cycle increased, the plasma generation time was longer, the energy provided was more continuous, and the film can be formed better. It can also be seen from the trend that when the duty cycle was low, the ability of the plasma to break bonds will be weakened, so when the duty cycle decreased, the film thickness will also decrease.

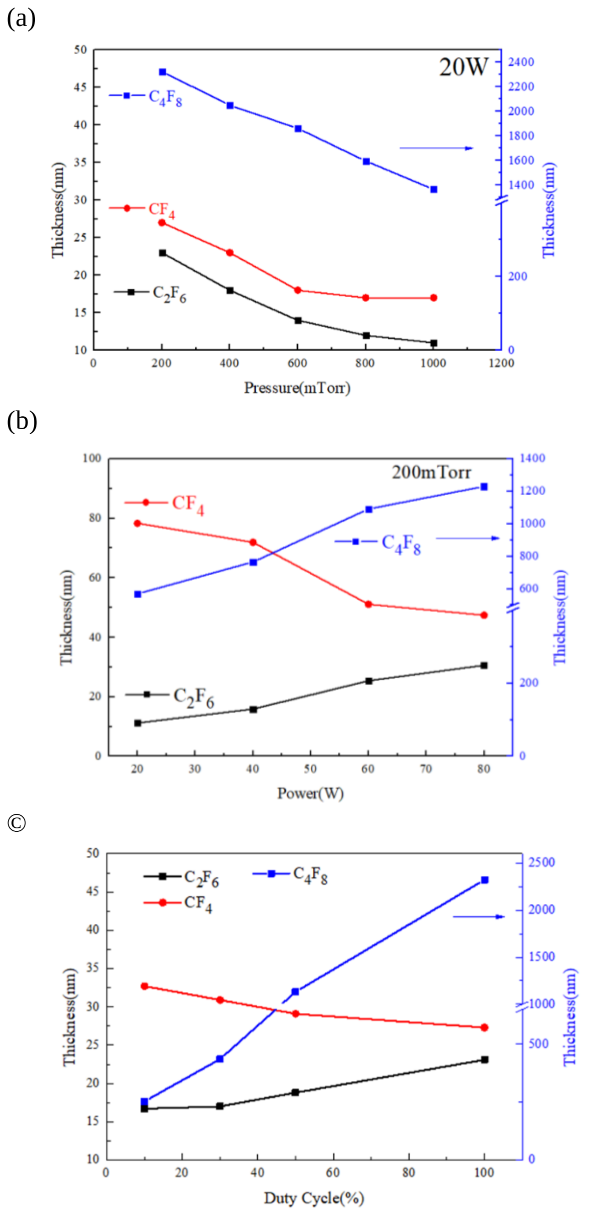

Figure 1. Changed (a)system pressure,(b)plasma power and (c)duty cycle film thickness of tetrafluoromethane, hexafluoroethane, and octafluorocyclobutane.

4.Conclusion

According to the thickness of the film, tetrafluoromethane will produce fluorine atoms after plasma dissociation for etching process, so when the plasma power increased, the film thickness will decrease; after hexafluoroethane undergoes plasma dissociation, the fluorocarbon films thickness still thin, and the reason was related to its own structure.Hexafluoroethane was a perfluorinated compound.All six hydrogen atoms in ethane were replaced by fluorine atoms; octafluorocyclobutane will produce CF_2 and CF_3 after plasma dissociation, and the deposition time was long, and the thickness of the film can be as thick as 2354 nm.

5.References

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