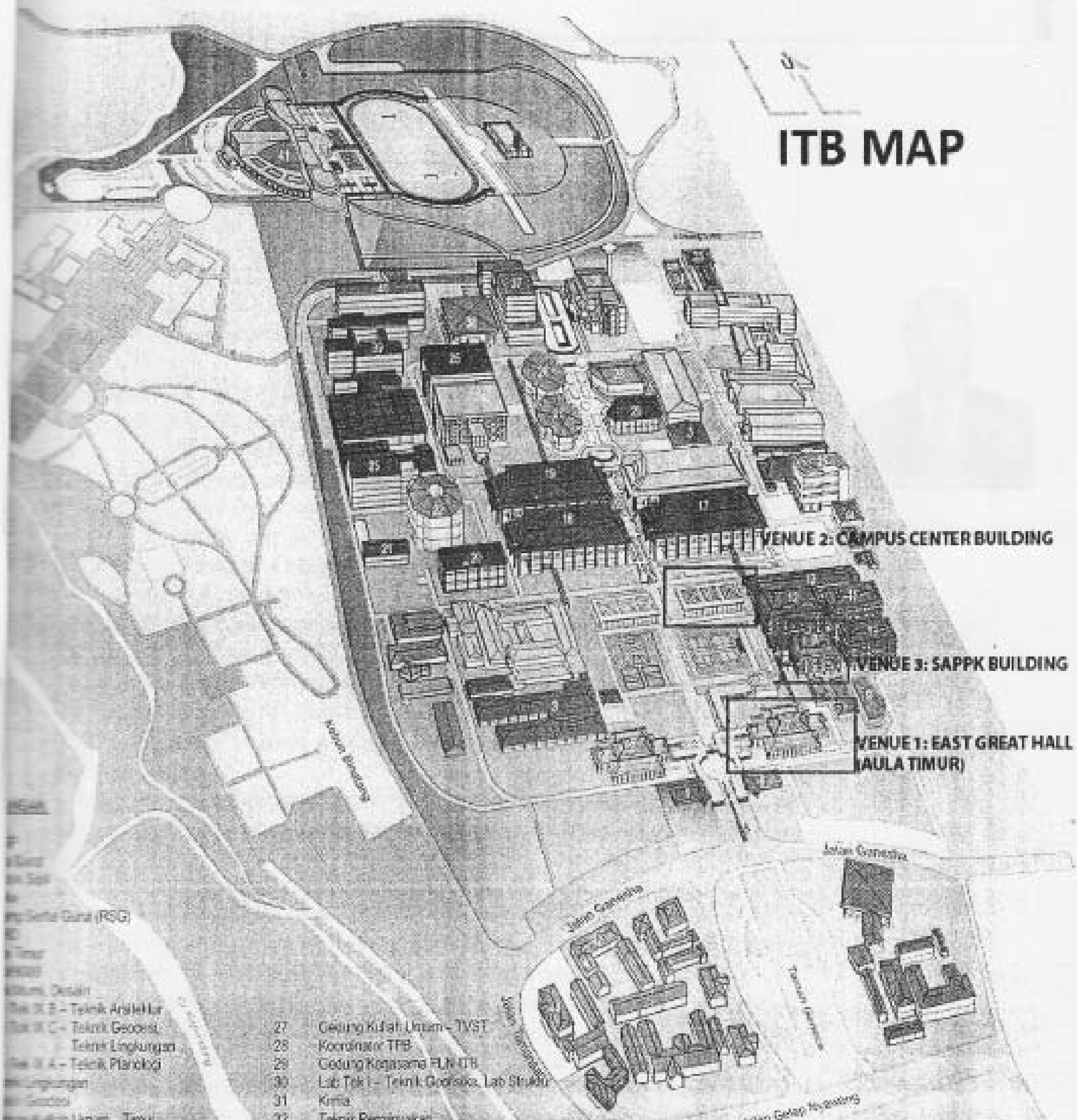
7th SEATUC SYMPOSIUM

4-6 MARCH 2013

INSTITUT TEKNOLOGI BANDUNG
INDONESIA

ITB MAP



...ng Serba Guna (RSG)
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...Tek IX C – Teknik Geodesi,
Teknik Lingkungan
...Tek IX A – Teknik Planologi
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...ung Kuliah Umum – Timur
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...Tek VIII – FMIPA, Teknik Elektro,
UPT Bahasa
...Tek V – PIKSI, Teknik Informatika
...Tek VI – Teknik Fisika, Teknik Kelautan,
Pusat Penelitian Kelautan
...ung Kuliah Umum – Barat
...Tek II – Teknik Mesin,
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PREFACE

Dear Colleagues

Welcome to Bandung

Welcome to Institut Teknologi Bandung,

It is indeed our honor to be the host of the 7th SEATUC Meeting and Symposium 2013, and also to welcome you all in Institut Teknologi Bandung. This is the second time, this very important event is performed in Bandung. I hope, again, we will have a good meeting, symposium and memorable time.

Since the establishment of the consortium and the first meeting at Shibaura Institute of Technology in Tokyo, Japan, we have done many activities and we have harvested lots of results. Not only the relationship among member universities that is absolutely strengthened, but also academic cooperation in the form of student mobility, which has increased the capacity building of member universities. Hybrid-Twinning Program as a flag activity of SEATUC, I believe, has been running very successfully. For example, here in ITB, all preparations of the 7th SEATUC Meeting and Symposium 2013 is done by Hybrid Twinning Program alumni who are now active as young academic members of ITB.

A consortium of university nowadays has become an important tool in building university cooperation. It creates forums, opportunities, networks that can be utilized by academic community. Sharing knowledge in the form of joint seminar could be a very good basic to understand the academic activities within the member university. SEATUC Symposium is a good example of this, where professors as well as students from each member university give presentation on what they are doing in their laboratory.

As in the previous SEATUC Meeting and Symposium, the meeting will always be carried out before the symposium. In such meeting, previous activities are reported and evaluated, current issues are discussed and also any issue that is concerned is also opened to be elaborated.

I hope that the 7th SEATUC Meeting and Symposium 2013 will be a successful event where all member universities will enjoy fruitful results and benefit.

Finally, I thank all the member universities for your presence here in ITB. Your time spent for coming to the 7th SEATUC Meeting and Symposium 2013 is highly appreciated. Thanks also to KMUTT as the current president of SEATUC, the host of the previous meeting and symposium together with SIT has prepared the material for the meeting.

I wish we can have good meeting and symposium, and enjoyable time during your stay in Bandung.

Prof. Akhmaloka, Ph.D
Rector of ITB

LIST OF SPEAKERS

7th SEATUC SYMPOSIUM 2013

Institut Teknologi Bandung, Indonesia, 5-6 March 2013
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	OS1: ENERGY, ENVIRONMENT & EARTH SYSTEM SCIENCE		
1	OS1-3	Rikiya Inoguchi	Shibaura Institute of Technology
2	OS1-4	Kazuhisa Ito	Shibaura Institute of Technology
3	OS1-5	Bui Xuan Thanh	Ho Chi Minh City University of Technology
4	OS1-6	-	
5	OS1-7	-	
6	OS1-8	M. Nor Said	Universiti Teknologi Malaysia
7	OS1-9	Nela Anjani L	Institut Teknologi Bandung
8	OS1-10	Sarah Ayunita	Institut Teknologi Bandung
9	OS1-11	Eidelweijs A. Putri	Institut Teknologi Bandung
10	OS1-14	Farid Nasir Ani	Universiti Teknologi Malaysia
11	OS1-15	Shahpur Khangholi	Universiti Teknologi Malaysia
12	OS1-16	Tan Sie Ting	Universiti Teknologi Malaysia
13	OS1-17	Dwina Roosmini	Institut Teknologi Bandung
14	OS1-18	Pham Minh Duyen	Ho Chi Minh City University of Technology
15	OS1-19	Wirianto, Eko	Institut Teknologi Bandung

	OS2: INFORMATION & COMMUNICATION TECHNOLOGY		
1	OS2-2	Hoang Van Hiep	Shibaura Institute of Technology
2	OS2-3	Nur Syafikah b. Samsudin	Shibaura Institute of Technology
3	OS2-4	Yusuke Ohta	Shibaura Institute of Technology
4	OS2-5	Toshiki Taniguchi	Shibaura Institute of Technology
5	OS2-6	Shuhei Murayama	Shibaura Institute of Technology
6	OS2-7	Hiroyuki Ebihara	Shibaura Institute of Technology
7	OS2-8	Yoshihiro Niitsu	Shibaura Institute of Technology
8	OS2-9	Nguyen Hoang Hai	Hanoi University of Science and Technology
9	OS2-10	Quoc-Hung Nguyen	Hanoi University of Science and Technology
10	OS2-11	Phan T.H. Nguyen	Ho Chi Minh City University of Technology
11	OS2-12	Nguyen Dai Hai	Hanoi University of Science and Technology
12	OS2-13	Hoang Viet Tran	Hanoi University of Science and Technology

	OS3: ARCHITECTURE, URBAN PLANNING & DESIGN		
1	OS3-1	Seyed Nima Moeinzadeh	Universiti Teknologi Malaysia
2	OS3-2	Sarajul Fikri Mohamed	Universiti Teknologi Malaysia
3	OS3-3	Nima Norouzi	Universiti Teknologi Malaysia
4	OS3-4	Mayam Shabak	Universiti Teknologi Malaysia
5	OS3-5	Hesamaddin Sotoudeh	Universiti Teknologi Malaysia
6	OS3-6	Hairul Nizam bin Ismail	Universiti Teknologi Malaysia
7	OS3-8	Fachrurrazi Muhammad	Institut Teknologi Bandung
8	OS3-9	Yasser Hafizs	Institut Teknologi Bandung
9	OS3-10	Hiroshi Noguchi	Shibaura Institute of Technology
10	OS3-11	Kazunobu Minami	Shibaura Institute of Technology
11	OS3-12	Pasunart Makanukhrao	King Mongkut's University of Technology Thonburi
12	OS3-13	Thanida Harnsere	King Mongkut's University of Technology Thonburi
13	OS3-15	Chin Siong Ho	Universiti Teknologi Malaysia
14	OS3-16	Sabeen Qureshi	Universiti Teknologi Malaysia
15	OS3-17	Rizki Tridamayanti	Institut Teknologi Bandung
16	OS3-18	Wasiska Iyati	Institut Teknologi Bandung
17	OS3-19	Norazam Othman	Universiti Teknologi Malaysia

	OS4: BIOSCIENCE, BIOLOGICAL & ENGINEERING SCIENCE		
1	OS4-1	Nur Ardawati Adnan	Universiti Teknologi Malaysia
2	OS4-3	Long Nguyen Duy	Hanoi University of Science and Technology
3	OS4-4	Do Thi Hoa Vien	Hanoi University of Science and Technology
4	OS4-6	Martha Aznury	Institut Teknologi Bandung
5	OS4-7	Naoto Yamashita	Shibaura Institute of Technology
6	OS4-8	Nguyen Thanh Trung	Shibaura Institute of Technology
7	OS4-9	Omori Yui	Shibaura Institute of Technology
8	OS4-10	Shintaro Oba	Shibaura Institute of Technology
9	OS4-12	Yuki Kawashima	Shibaura Institute of Technology
10	OS4-13	Kanako Takizawa	Shibaura Institute of Technology
11	OS4-14	Nitnipa Soontorngun	King Mongkut's University of Technology Thonburi
12	OS4-15	Piyasuda Thepnok	King Mongkut's University of Technology Thonburi
13	OS4-16	Teerapol Saleewong	King Mongkut's University of Technology Thonburi
14	OS4-17	Takaaki Ishibe	Shibaura Institute of Technology
15	OS4-19	Tatsuya Tsuzuki	Shibaura Institute of Technology
16	OS4-20	Wataru Kobayashi	Shibaura Institute of Technology
17	OS4-21	Hoang Khanh Duy	Hanoi University of Science and Technology
18	OS4-23	Yoshihiro Hirano	Shibaura Institute of Technology
19	OS4-24	Emi Shikishi	Shibaura Institute of Technology
20	OS4-25	Yusuke Mizutani	Shibaura Institute of Technology
21	OS4-26	Toru Yamashita	Shibaura Institute of Technology
22	OS4-27	Tatsuya Yamadera	Shibaura Institute of Technology
23	OS4-28	Takuya Katukawa	Shibaura Institute of Technology
24	OS4-29	Hirano Hiroki	Shibaura Institute of Technology
25	OS4-30	-	
26	OS4-31	Mohd Ismail Abd Aziz	Universiti Teknologi Malaysia
27	OS4-32	Mohd Azizi Che Yunus	Universiti Teknologi Malaysia

	OS5: ROBOTICS & MECHANICAL ENGINEERING		
1	OS5-3	Nguyen Hoang Tung	Hanoi University of Science and Technology
2	OS5-4	Masayuki Kobayashi	Shibaura Institute of Technology
3	OS5-5	Nguyen Truong Phi	Shibaura Institute of Technology
4	OS5-6	Hiroshi Hasegawa	Shibaura Institute of Technology
5	OS5-7	Shun Takahashi	Shibaura Institute of Technology
6	OS5-8	Yuta Nagami	Shibaura Institute of Technology
7	OS5-9	Atsushi Hori	Shibaura Institute of Technology
8	OS5-10	Nur Safwati Mohd Nor	Shibaura Institute of Technology
9	OS5-11	Bhanupong Petchlert	Shibaura Institute of Technology
10	OS5-12	Mohd Azuwan Bin Mat Dzahir	Shibaura Institute of Technology
11	OS5-13	Pham Ngoc Pha	Shibaura Institute of Technology
12	OS5-14	Dung Anh Nguyen	Shibaura Institute of Technology
13	OS5-15	Mohd Noor Arib Rejab	Universiti Teknologi Malaysia

	OS6: MATERIALS SCIENCE & ENGINEERING		
1	OS6-2	Atikah Mohd Nasir	Universiti Teknologi Malaysia
2	OS6-3	Pham Mai Khanh	Hanoi University of Science and Technology
3	OS6-6	Pham Quang	Hanoi University of Science and Technology
4	OS6-7	Somsak Siwadamrongpong	Suranaree University of Technology
5	OS6-8	Somsak Siwadamrongpong	Suranaree University of Technology
6	OS6-9	Somsak Siwadamrongpong	Suranaree University of Technology
7	OS6-10	Somsak Siwadamrongpong	Suranaree University of Technology
8	OS6-11	Ersyzario Edo Yunata	Shibaura Institute of Technology
9	OS6-12	Istiroyah	Shibaura Institute of Technology
10	OS6-13	Muhammad Zaimi	Shibaura Institute of Technology
11	OS6-14	Satoru Yukawa	Shibaura Institute of Technology
12	OS6-15	Azizul Helmi Bin Sofian	Shibaura Institute of Technology
13	OS6-16	N. Tugur Redationo	Shibaura Institute of Technology
14	OS6-17	Foo Jin Hoe	Shibaura Institute of Technology
15	OS6-18	Don Kaewdook	Shibaura Institute of Technology
16	OS6-19	Ryo Suenaga	Shibaura Institute of Technology
17	OS6-20	Teguh Dwi Widodo	Shibaura Institute of Technology
18	OS6-21	Tatsuhiko Aizawa	Shibaura Institute of Technology
19	OS6-22	Pham Quang	Hanoi University of Science and Technology
20	OS6-23	Nguyen Tanh Liem	Hanoi University of Science and Technology
21	OS6-24	Bach Trong Phuc	Hanoi University of Science and Technology

	OS8: TRANSPORTATION ENGINEERING		
1	OS8-1	Tran Thanh Tung	Shibaura Institute of Technology

	OS9: APPLIED MATHEMATICS & INFORMATICS		
1	OS9-2	Dung T. Ho	Ho Chi Minh City University of Technology

	OS10: ELECTRICAL ENGINEERING		
1	OS10-2	Mohd Nabil Bin Muhtazaruddin	Shibaura Institute of Technology
2	OS10-3	Nguyen Nhat Nam	Shibaura Institute of Technology
3	OS10-4	Mohd Nabil Bin Muhtazaruddin	Shibaura Institute of Technology
4	OS10-5	Ryuichi Ogura	Shibaura Institute of Technology
5	OS10-6	Zulkarnain A. Noorden	Shibaura Institute of Technology

DRY PLASMA ETCHING FOR MICRO-PATTERNING ONTO THE DLC COATING

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ABSTRACT

Micro-patterning has become a new keyword in the industries; e,g, designed micro-textures are imprinted on to the micro-electronic devices, sensors, optics, molds and dies. Among several methods using wet and dry etching processes, high density oxygen plasma etching process has been developed. This process is characterized by no use of hazardous solvents, high controllability in etching, uniformity in etching and high resolution. In the present paper, micro-patterning behavior is described by using the DLC-coated silicon wafer. Micro-grooves and micro-grids are uniformly formed onto the DLC coating with highly accurate dimensions and depth profile. Reactive ion etching behavior is discussed in this micro-grooving with different groove widths. Plasma etching process is optimized to control this local etching process both in micro-grooving and micro-gridding.

1. INTRODUCTION

Micro-patterning has become a new keyword in the industries. Micro-electric devices, sensors, and optical elements require for designed micro-textures on their surfaces to be imprinted by micro-forming with micro-textured molds and dies (Kim, 2012).

Several methods have been developed for this micro-patterning. Micro-patterns were successfully formed by the high density oxygen plasma etching on the DLC layer with the thickness of 5 μm; SKD11 mold-die with micro-patterned DLC coating was used to duplicate this micro-pattern onto polymer and glass products via the mold-stamping (Aizawa, 2011). Nano-imprinting processes were also effective to make micro- and nano-patterns onto polymer sheets or thin metallic substrates (Guo, 2007; Kim, 2012).

In this study, two dimensional masking is prepared onto the DLC coating; the initial mask is made from resin and oxide layers on the silicon (Si) substrate by using the chemical etching process. High density oxygen plasma etching is applied to make dry etching for fine three dimensional micro-patterning. The effect of processing parameters onto this etching behavior is discussed to search for optimum processing parameters.

2. EXPERIMENT

Our developing high density RF-DC plasma etching system was first introduced. Different from the conventional plasma etching, no chemical agents are utilized in this process. DLC-coated test-piece was used to measure the removal rate. DLC-coated silicon sample with initial micro-pattern was also used to describe the oxygen plasma etching behavior.

2.1 Plasma Etching System

Plasma etching system used in this experiment is shown in Fig. 1. In this etching process, only pure oxygen gas is used to remove the DLC coating. This system has three main processing parameters: i.e. RF-voltage, DC-bias and oxygen gas pressure. In parallel with these parameters, experimental set-up has influence on the etching process; e.g. spatial position of dipole electrode to generate RF-plasmas, distance between this electrode and cathode, and distance between the substrate electrode. Typical experimental set-up is depicted in Fig. 2. In the following plasma etching experiments, the above parameters are varied to find the optimal feasible range in those parameters for efficient removal of DLC coating. Under optimum selection of parameters, micro-patterning is performed to describe the etching behavior. This machine has the following characteristics with radio frequency (RF) working around 2 MHz. This RF-plasma is directly controlled by its voltage from 60 V to 250V. DC bias is also controllable from 0V to 600V. The pressure is varied from 10 Pa to 100 Pa with automatic gas flow rate control. In this study, the parameters were varied as follows; the RF voltage is varied in the range of 200V to 250 V, DC-bias,-400V to 600 V and gas pressure, 20 Pa to 40 Pa. Base pressure was below 0.1 Pa.

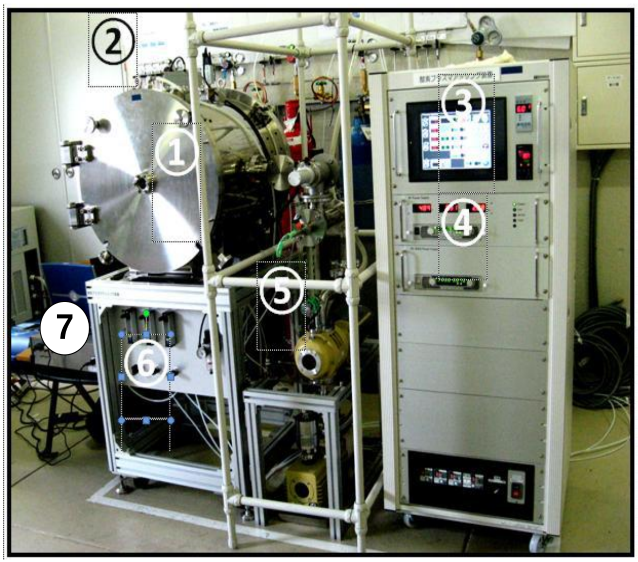


Fig. 1: High density plasma etching system. 1: Chamber, 2: RF-plasma generator, 3: Control-panel, 4: Electric sources, 5: Evacuation system, 6: Gas supply, 7: Plasma Diagnosis (PMA-11)

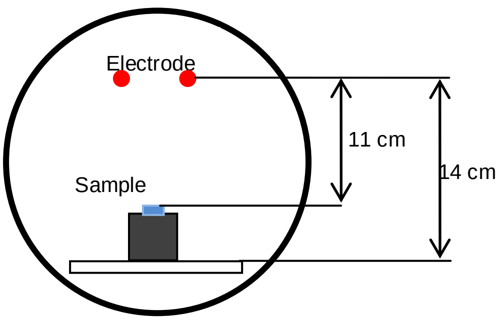
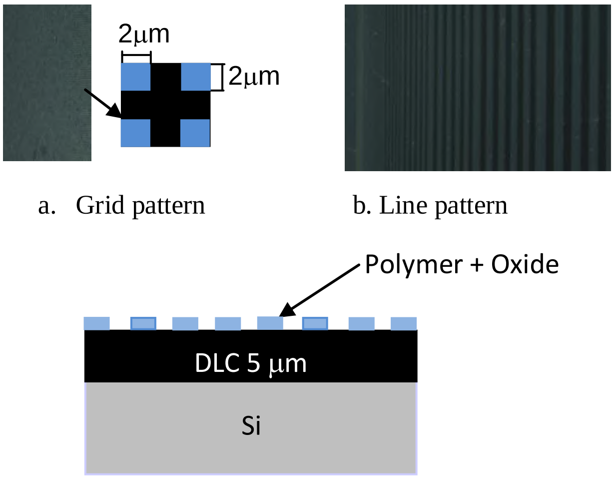


Fig. 2: A Typical experimental set-up for plasma etching.

2.2 Sample

The sample used in experiment is shown in Fig. 3.

Top view



a. Grid pattern

b. Line pattern

c. Side view.

Fig. 3: Geometric configuration of samples.

Silicon wafer was employed as a substrate, and, subsequently DLC coating and polymer oxide mask were stacked onto it. The thickness of silicon wafer, DLC coating and oxide mask were 0.525 mm, 5 μm and 1.2 μm, respectively. There are two kinds of micro patterns: micro-grids and micro-lines. Grids pattern have a size of 2 x 2 μm as shown in Fig 3a). The width of line pattern varies in a series of 3, 4, 5, 7, 10, 20, 30, 50, 70 and 100 μm in Fig. 3b).

3. RESULTS AND DISCUSSION

The etching rate was defined by the ratio of the removed DLC thickness to the removal time required. The plasma etching process worked optimally on RF-voltage of 250 V, DC bias, -400 to -600V and the pressure, 20 Pa. The etching rate ranged over 1.193 to 1.633 nm/s. It is used for further research to remove the DLC coating with thickness of 5 μm.

3.1 Line Pattern

Laser reflection profilometer (Lasertec HD 100) was employed to measure the micro-line pattern. Fig. 4 and Fig. 5, depicted the depth profile of etched DLC-coated sample under the processing condition where the RF-voltage was 250 V, the DC-bias, -600 V, the pressure, 20 Pa and the duration time, 3000s. Remembering that the initial DLC coating thickness was 5 □m, the original DLC coating in the un-masked regions was completely removed. In addition, the flat surface of DLC coating before etching was successfully wrought to a micro-grooved DLC coating, irrespectively of the micro-line widths down to 20 □m. When the initial line width is less than 20 □m, the micro-groove pattern becomes away from the step-wise depth profile, as seen in the micro-grooves at the left-hand side of Fig. 5. This irregularity might come from the micro-etching process in the narrowed channels in the masking.

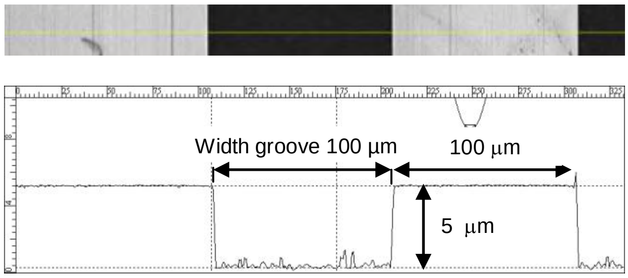


Fig. 4: Depth profile of etched sample by using the wider line-patterned mask in case where RF-voltage was 250 V, the DC bias, -600 V, the pressure, 20 Pa, and the duration time, 3000s.

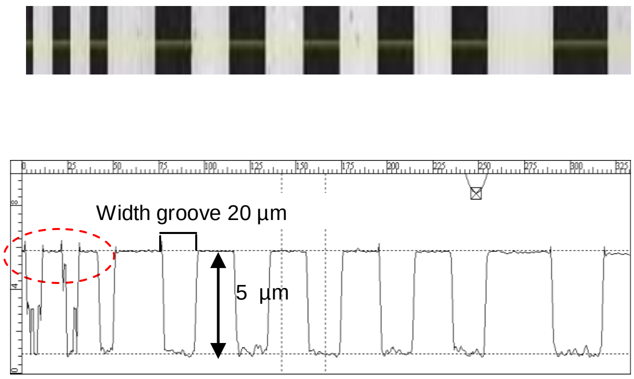


Fig. 5: Depth profile plasma etching by using the narrower line-pattered mask in case where the RF-voltage was 250 V, the DC bias, -400 V, the pressure, 20 Pa, and the duration time, 4000s.

3.2 Grid Pattern

Optimized processing parameter was used to make micro-grid patterning onto DLC-coating. Figure 6 depicted the SEM cross-sectional view of grid-pattern sample after etching.

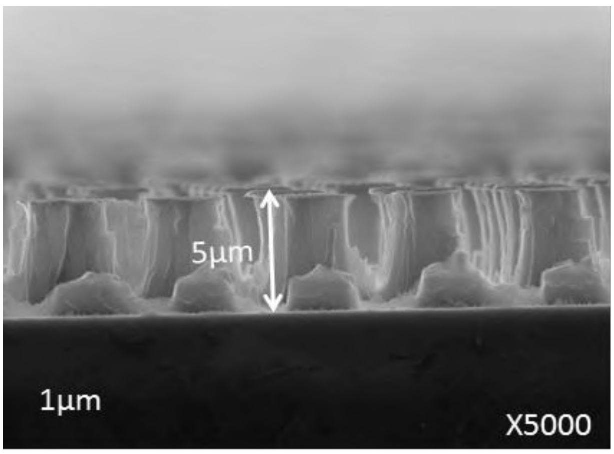


Fig. 6: SEM image of etched sample by RF (250 V), DC-bias (-600 V), pressure (20 Pa), Time (3000s).

In general, higher DC-bias and lower pressure drive the etching process to be enough strong to make severe damage even to DLC coating. In fact, as seen in Fig. 6, etched columns were timbered or broken after etching. On the other hand, the duration time to perfect removal of DLC coating in the un-masked regions must be significantly delayed by much reduction of DC-bias and increase of pressure. Here, only the duration time was reduced from 3000 s to 2000 s as the first remedy to reduce the damage onto DLC coating. Figure 7 depicted the SEM cross-sectional image of etched sample by new processing conditions. Damages to DLC-columns were minimized by this change of duration time in etching.

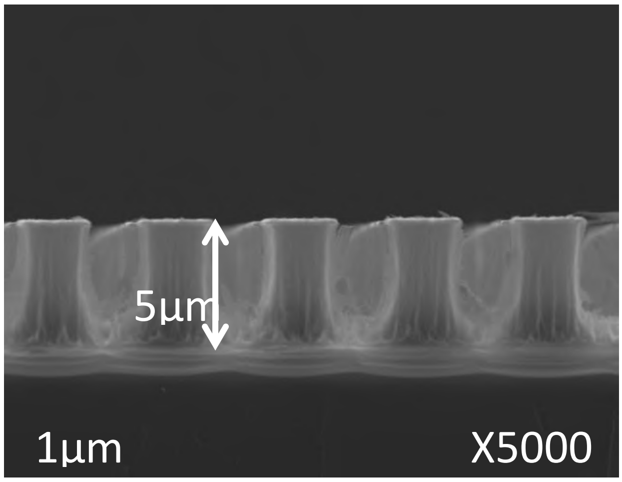


Fig. 7: Fig. 6: SEM image of etched sample by RF (250 V), DC-bias (-600 V), pressure (20 Pa), Time (2000s).

4. DISCUSSION

From the all cross-sectional views of the grid-pattern sample by SEM, micro-etching process must be reconsidered to be free from irregular shaping in micro-patterning. In particular, over-etching comes from excess etching time and faster reactive ion etching (RIE).

Final determination of plasma etching process must be considered. Even after the DLC coating is removed completely, oxygen ions (O) maintain to bombard on the silicon substrate with no reaction. Then ions (O) tend to bounce off the side walls of DLC coating. Due to oxygen ion bombardment onto the sidewalls of DLC (C), carbon is eroded by the reaction between O and C in DLC to form CO, to be ejected out of chamber by a vacuum pump. In this manner, over-etching is induced by this bombardment.

Regarding the problems mentioned above, it is necessary to utilize the in-situ plasma diagnosis to investigate what occurs during the plasma etching process. Remembering that the spectrum of CO peak appears at wavelength of 256.83 nm after Ref. (Aizawa, 2012), we can predict what occurs during the etching process. Etching process has been completed when the intensity of measured CO peak is minimized.

The etching parameters above result in very fast RIE. It is characterized by relatively rapid etching rate (Redationo, 2011). RIE were quickly affected by ion density and movement of oxygen ions. Oxygen ions are very fast to get into the groove below 20 μm width so that collisions between ions become more frequent and the ion cannot vertically bombard onto DLC surface. Consequently, all groove-pattern under the width of 20 μm is not perfectly etched, resulting in the cone-like shape. The plasma etching in the groove size over 20 μm is performed perfectly. That is, it is proved oxygen ions easily enter and exit through this pattern during bombardment onto DLC coating.

To solve this problem, the absolute control of plasma etching parameters has to be considered; i.e. movement of the ions can be slowed by reducing the ion density. This can be done by increasing the gas pressure, and lowering the RF power and DC bias. In order for the proper analysis to determine the density and movement of oxygen ions during the etching process in the chamber, Langmuir probe is indispensable for the system. With the help of Langmuir probe, some important plasma parameters are obtained, such as electron density, electron temperature, plasma potential, floating potential and so on. From the available data, the kinetic energy of the ion is calculated so that it can estimate the movement of oxygen ions and density.

5. CONCLUSION

Plasma etching has successfully created a micro-grid-patterned (2 x 2 μm^2) DLC coating with the thickness of 5 μm on silicon substrate. Over-etching can be overcome with appropriate selection of duration time and processing parameters. controlling plasma etching.

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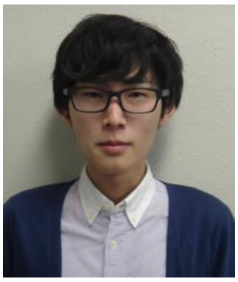

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