《微纳光电子材料与器件工艺实验》
Laboratory of Micro- and Nanofabrication for Electronic and Photonic Devices

实验 3　　刻蚀
Lab 3　　Etching

Lecturer: Xing Sheng
Time: 2017-11-18
Place: Weiqing Building 113

1. Objectives

In this lab, we introduce two different etching methods: the reactive ion etching (RIE) method to dry etch materials (silicon, SiO_2, photoresist), and wet etching method to remove SiO_2 films on Si. We will etch silicon, SiO_2 and photoresist respectively by SF_6, CHF_3 and O_2 plasma, observe and measure the etched patterns. In addition, we will etch SiO_2 films on Si by using buffered hydrofluoric acid (BHF), and observe the surface change from the hydrophilic state to the hydrophobic state.

2. Materials and Equipments

silicon pieces with SPR220-v3.0 photoresist patterns (> 3)
silicon pieces with SiO_2 layer on top (>10 pieces, by PECVD, thickness ~ 500 nm)
petri dish, 4 inch (>10)
plastic beakers (> 2)
gloves (>2 boxes)
face masks (>20)
cleanroom white papers (>1 bag)
wafer tweezers (>5)
buffered hydrofluoric acid solution (1:6) (also called BHF or BOE)
DI water bottle
acetone bottle
alcohol bottle

safety gowns for HF etching (face masks, aprons and rubber gloves)
RIE-100
optical microscope
Dektak-150 profilometer

3. Procedures

preparation:

- turn on N_2 gun

- turn on profilometer
- turn on RIE-100

RIE dry etch 1:

- observe the silicon samples under microscope, measure the patterned photoresist (SPR220-v3.0) thickness
- etch the samples using SF_6 gas for 2 mins
- observe and measure the pattern thickness again, calculate the etched silicon thickness and etching rate
- remove the photoresist layer rinsing by acetone, alcohol and DI water
- observe and measure the pattern thickness again

RIE dry etch 2:

- etch another new Si sample with photoresist patterns using SF_6 gas for 2 mins
- observe and measure the pattern thickness
- etch the photoresist layer using O_2 gas for 3 mins
- observe and measure the pattern thickness again, calculate the etched photoresist thickness and etching rate
- etch the photoresist layer using O_2 gas for 10 mins, to completely remove the photoresist layer
- observe and measure the pattern thickness again
- run chamber clean process

wet etch:

- prepare buffered HF (BHF or BOE) solution on a plastic beaker
- test the water wetting ability on the silicon pieces with a SiO_2 layer
- dip the samples into BHF for about 3 mins
- observe the color change, and test the water wetting ability again

surface modification by plasma:

- treat the HF cleaned Si sample with O2 plasma for 2 mins
- test the water wetting ability again

Questions

- Why do we use SF_6 and O_2 plasma to etch silicon and photoresist, respectively?

- If we want to dry etch GaAs, what will be the suggested gas species? Why?

- Write down the chemical reactions for dry etching silicon, photoresist, SiO_2, GaAs, InP and Al.

- What are the differences between wet etching and dry etching? Illustrate the different etched profiles of KOH solution etched and SF_6 dry etched (001) silicon wafers.

- How does the chamber pressure affect the material etching?
- How does the plasma power affect the material etching?
- Why shall we clean the chamber after etching? What are the clean gas species?
- List the differences among RIE, DRIE, ICP-RIE.

附录一：反应离子刻蚀设备的使用

一 开机（使用前先网上预约）

依次打开机台前面板上的电源开关、循环水机的电源开关、空气压缩机的电源开关、再打开所需要的工艺气体的开关（面板最上面的旋钮旋到 open），并检查减压阀主表压力（> 0.5 MPa）和副表压力（0.1-0.2 MPa）；

二 软件操作及工艺过程

- 双击桌面上的 RIE.exe；
- 软件开机自检；
- “真空流程”，机台自动进行抽真空流程，结束后弹窗提示；
- “充气开盖”，机台自动进行充气流程，流程结束并弹窗提示；
- 打开上盖，放入样品，关闭上盖；
- “真空流程”，机台自动进行抽真空流程，结束后弹窗提示；
- “加载工艺”，自动加载选定的工艺菜单；
- “运行工艺”，工艺自动开始运行，做好工艺记录，工艺结束；
- “真空系统”，选择”关闭高阀”，等待高阀关闭；
- ”充气开盖”，流程结束并弹窗提示；
- 取出样品，做下一个样品直至结束实验，关闭上盖
- “真空流程”，机台自动进行抽真空流程，结束后弹窗提示；
- “真空系统”，选择”关闭泵组”，机台自动关闭泵组并停止抽真空，分子泵转数降到 0 以后弹出窗提示；
- 点击退出，电脑关机；

三 关机

依次关闭工艺气体（面板最上面的旋钮旋到 close，气瓶和减压阀不关）、空气压缩机的电源（出气阀不关）、循环水机的电源（进出水阀门不关）、最后关闭机台前面板的电源

四 整理台面保持卫生，做好实验记录

备注：

1）工艺开始前气体和射频有一定的延时稳定时间，当前步计时开始为工艺开始的标志。
2）“停止工艺”按键是在工艺进行中立即结束工艺。停止工艺按键只有在工艺开始后才能使用。
3）自动流程之间有互锁，任何流程进行中不要再次点击流程按键，否则弹窗提示“请等待当前进程结束”。
4）“结束进程”按键是立即结束当前进程。正在运行的自动流程会立即停止在当前状态。按下此按键后必须关闭整个程序后再重新启动，才能运行自动流程。此按键只有在需要强制退出自动流程并关机的情况下才能使用。

5）水、气注意事项：

- 气瓶的开关和减压阀一直保持开启状态，使用时只开关最上面的那个阀门（写有 Open - Close 字样），工作时减压阀副表压力应保持在 0.1-0.2MPa 之间，主表压力不低于 0.5MPa；

- 循环水机的进出水阀门一直保持开启状态，使用时只开关电源；

- 空气压缩机的出气阀门一直保持开启状态，压力保持 0.5MPa 使用时只开关电源；

- 真空泵的开关在软件中控制