INFLUENCE OF D.C. BIAS IN REACTIVE ION ETCHING

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ABSTRACT

The influence of the cathode material on d.c. bias has been evaluated. We show the relation between the d.c. bias, and etch rate (anisotropy), and the cathode size. Theses both evolutions can be used to forsee the setting of parameter such as r.f. power, to obtain a given etch rate for any kind of reactor geometry.

1. INTRODUCTION

Since two or three years studies have been performed to handle reactive ion etching. Dr Lehmann (1) has shown the possibilities of the system to give anisotropics etch profiles. J.L Mauer (2) show a loading effect with respect to the efficency of the reaction and the reactant concentration. G.C Schwartz (3) noticed the formation of polymers varying the parameters of the dischange. All theses works has been often performed in anonly reactor to show the importance of chemical reactions. It is often imposible to use the results oltained, in an other reactor.

In this paper the parameter are the same but we will demonstrate how to transfert results from a systeme to an other. We will see the impact of the cathode material and size on d.c. bias and etch rates.

2. APPARATUS

All our experiments are performed in two commercially aviable r.f. diode sputter etching systems (4). Both systems are equiped with stainless-steel walls and stainless-steel 22 or 60 cm diameter cathodes. The cathodes are water cooled and can be covered with wafers of various materials such as copper, silicon, silicon dioxyde, tungstene. Using two grounded shields we obtain two cathode sizes of 22 and 11 cm diameter. The cathode-anode distance can vary from 0 to 10 cm.

Discharges are generated at 13,56 MHz, for differents power levels, in SF6 or CHF3. SF6 is used for silicon or polysilicon etching, while CHF3 is used for silicon dioxyde etching. By means of a suitable r.f. filter positioned at the output of the mathching box, we measure the d.c. bias of the discharge.

The gas pressure is held constant at 18 mTorr for a given gas flow of 8 Scc/mn.

3. RESULTS AND DISCUSSION

EFFECT OF THE CATHODE MATERIAL

Figures 1 and 2 indicate the relationship between the d.c. bias and the power for tungstene, SiO2, Cu an Si as cathode material, in SF6 or CHF3 discharges.

In CHF3 discharges, Copper, silicon and tungstene etch rate are very low (Vetch # 0), while the etch rate of SiO2 is important : i.e. 500 Å/ mn for 100 W incident power.

The decrease of the d.c. bias, using SiO2 cathode, can be only esplained by an important formation of volatil compounds such as SiF3 and O2 which induces a reduction of the impedance of the discharge. We can hope that it will be possible to monitor the etch rate of SiO2 by observing the bias évolution.

In SF6 discharges we observed that : copper is not etched ; SiO2 is etched slowly (i.e. 300 Å/mn ; 100 W) and W is etched as fast as Si (i.e. 2000 Å/mn 100 W). In the same way that CHF3 ; the impedance of SF6 discharge vary with the presence of an amount of new compounds.

We conclue that the decrease of d.c. bias follow the importance of the etch of the cathode.

EFFECT OF THE ELECTRODE SPACING

As we can see in figure 3 and 4 the electrode spacing is not an important parameter. Figure 3 schows the relationship between d.c. bias and incident power for differents spacing. Figure 4 shows the relationship between the etch rate of silicon and the electrode spacing at a given power (100 W)

EFFECT OF THE CATHODE SIZE

Evolutions of d.c. bias with incident power figure 5 are almost linear, and for a given incident power d.c. bias decreases when electrode size increases.

If we draw the evolution of the d.c. bias versus the power density, we always obtain three separated curves with respect to the cathode size. But if we draw the evolution of the d.c. bias as a function of the ratio of the incident power to the cathode diameter, we obtain a straight line as shown in figure 6.

There is no obvious theorical reasons to explain this evolution. But the use of this empirical law allows to forsee the electricals parameters of SF6 discharges for severals cathode sizes.

EFFECT OF THE D.C. BIAS ON ETCH CARACTERISTICS

Etch rates have been evaluated on silicon wafers of 3" diameter, covered by an HPR 304 photoresist mask, by measuring etched steps with a Talystep.

ETCH PROFILE

The aim of the R.I.E. system is to improve the etch anisotropy using the d.c. bias effect. We can hope that by increasing the d.c. bias we will emphasize the etch anisotropy.

To increase the d.c. bias we can lower the presure figure 7, or, for a given pressure, increases the incident power figure 5.

In the case of silicon etching by SF6 we observe an increase of the etch isotropy with increasing d.c. bias obtained by varying the incident power figure 8a (5). We also observe a deacrease of etch isotropy with increasing the d.c. bias obtained varying the gas pressure (figure 8b). In conclusion : for the same evolution of the d.c. bias we observe two opposits effects on the etch anisotropy. So there is no relationship between d.c. bias and etch anisotropy.

In the case of silicon dioxyde, etched by CHF3, we obseve a perfect anisotropy at all d.c. bias.

ETCH RATE :

The Etch rate of silicon versus incident power is shown in fig. 9 for two cathodes sizes. We obtain two separate curves. For a given power, when the cathode size increases the etch rate decreases. The etch rate versus d.c. bias is shown in fig. 10. For low d.c. bias we have a single evolution between etch rate and d.c. bias for all electrode sizes. For d.c. bias larger than 175 we observe fluctuations produced by a change of the discharge composition when the ion and electron acceleration is too high.

In the same way the SiO2 etch rate seems to follow the same law than silicon. Tableau I shows the constant etch rate of SiO2 for three cathode zizes, with the same d.c. bias.

TABLE I

Ø	60	22	11	cm
W	300	100	20	watt
|V|	520	520	470	volts
Vatt	500	500	470	Å/mn

4. CONCLUSION :

It has been demonstrate that the etch rate is proportional to the d.c. bias, and is independent of the electrodes size for inert electrodes. To obtain a given etch rate it is only necessary to adjust the input power to establish the corresponding d.c. bias.

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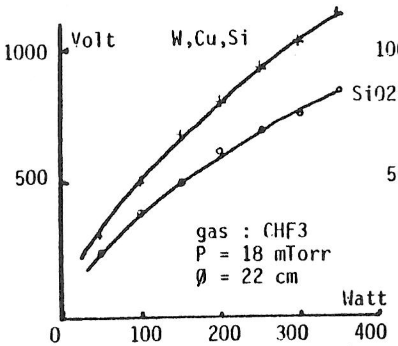

Figure 1: Relationship between d.c. bias and incident power for different cathode materials

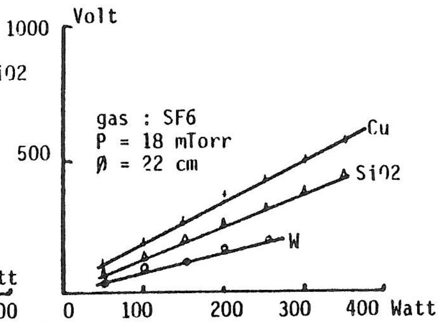

Figure 2: Relationship between d.c. bias and incident power for different cathode materials

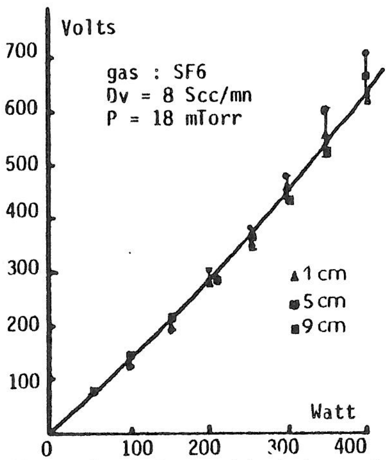

Figure 3 : Relationship between d.c. bias and incident power in SF6 discharge for different electrode spacing

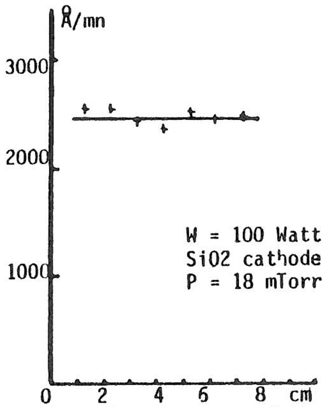

Figure 4: Influence of the electrode spacing on the etch rate of Si in SF6 discharge

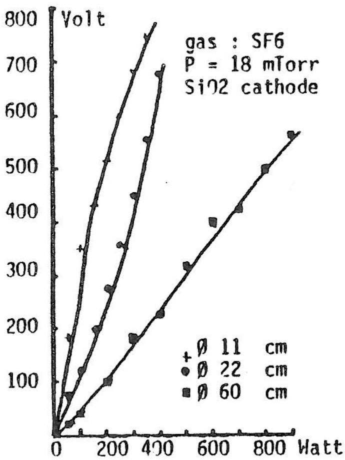

Figure 5 : Relationschip between d.c. bias and incident power for various cathode size

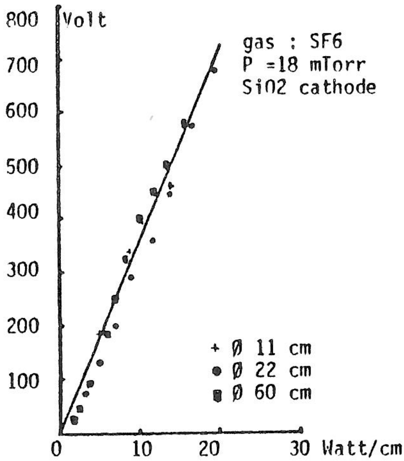

Figure 6 : Relationschip between the d.c. bias and the ratio : incident power to diameter of the cathode

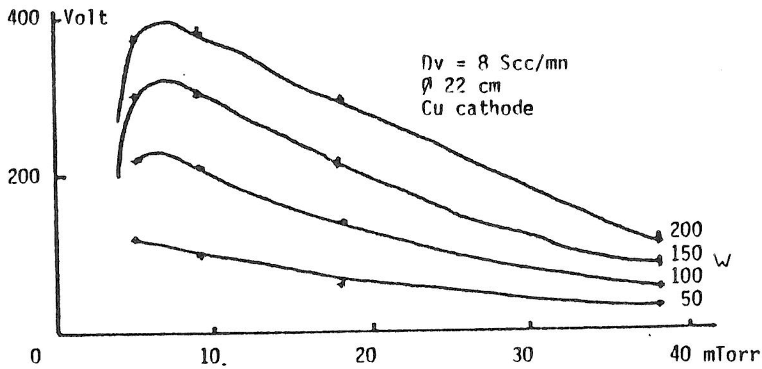

Figure 7 : Relationship between d.c. bias and pressure in an SF6 discharge, for different incident power

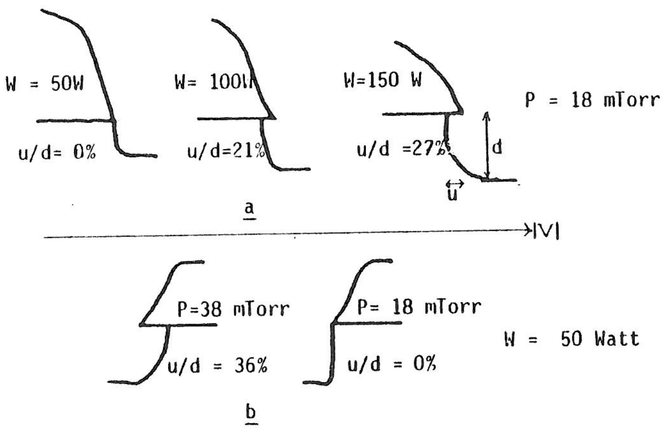

Figure 8 : Variation of the etch anisotropy of Si in SF6 discharges with : a : the incident power b : The pressure ; SiO2 cathode

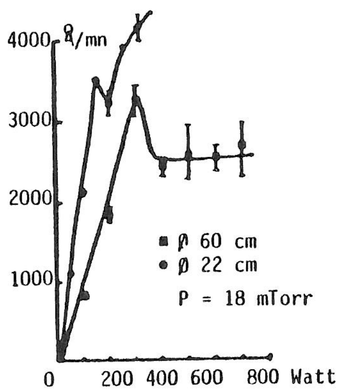

Figure 9 : Etch rate of Si in SF6 discharge versus the incident power for two cathode size

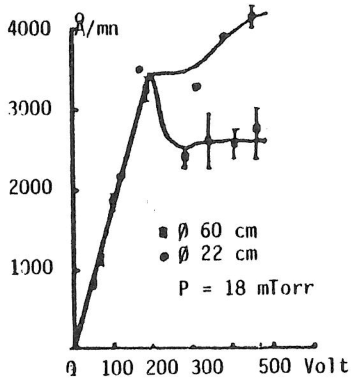

Figure 10 : Etch rate of Si in SF6 discharge versus the d.c. bias for two cathode size