Plasma (電漿)

Plasma定義: partially ionized gas (離子化程度至可發光,約十萬分之一以上)

- 電漿之特性: 高能量, 可導電, 會發光.

- 電漿之應用:
  - ➢工業生產

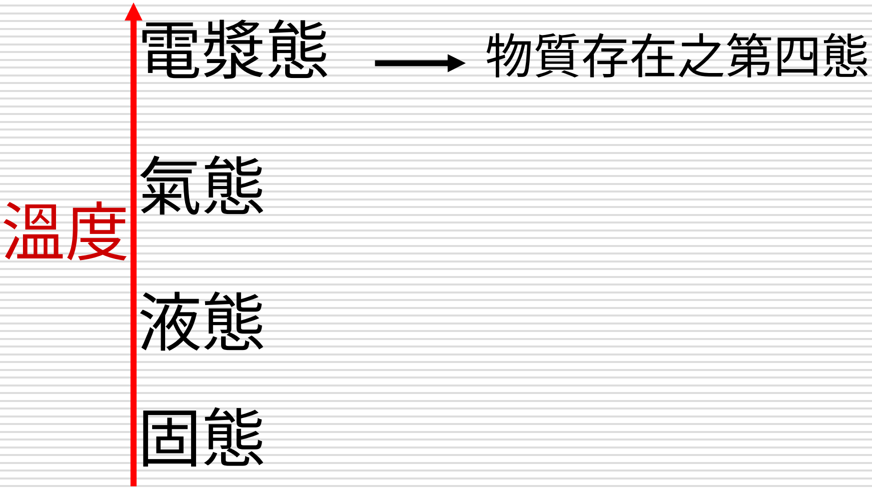
    Traditional industry: welding(焊接), melting(熔煉),

    IC industry: Ion implantation, Thin film deposition (PECVD, Sputtering),
    Etch (RIE), Plasma cleaning, Exposure (Light source)

.

  - ➢日常用品: 日光燈, 霓虹燈, 電視, 真空壓力計…

- 電漿產生之方法:
  1) By heating
  2) By electric field



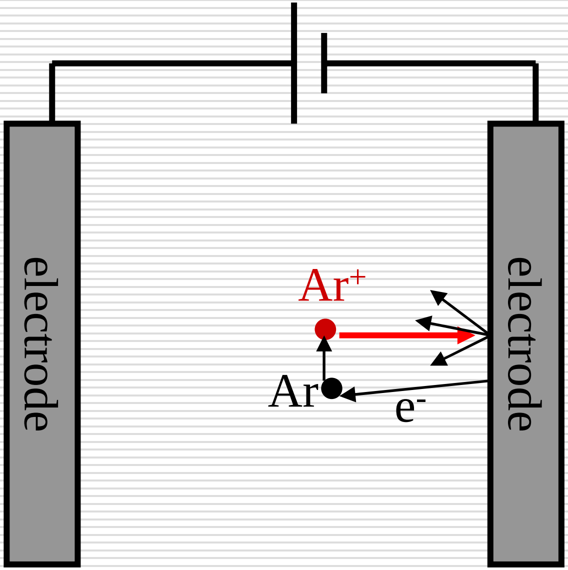
溫度

電漿態 → 物質存在之第四態

氣態

液態

固態



- 影響電漿生成之因子:
  1) 電場大小
  2) 氣體壓力
  3) 電極材料

- 電漿內產生之主要三種反應:

分解 $e^- + X_2 = 2X + e^-$

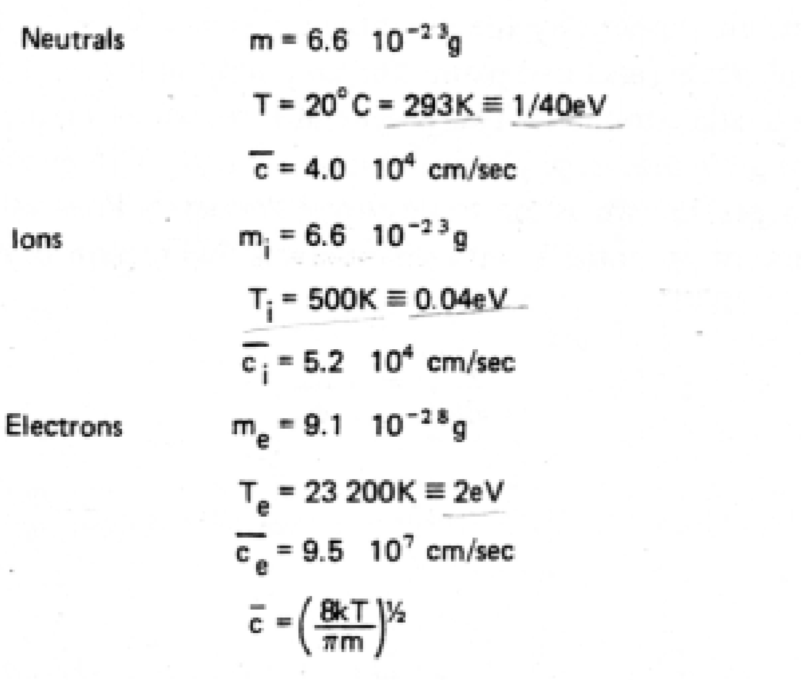
離子化 $e^- + X_2 = X_2^+ + 2e^-$ $(e^- + X = X^+ + 2e^-)$

激發 $e^- + X_2 = X_2^* + e^-$

PECVD主要應用了電漿內哪種？	分解反應
HDPCVD主要應用了電漿內哪種？	分解反應 + 離子轟擊
RIE主要應用了電漿內哪種？	分解反應 + 離子轟擊

• 電漿內之電場與電位

電漿為一等電位體,電子與離子均勻分佈, 且無序的運動. 因此任何物體置於電漿內皆會受到電子與離子之撞擊,由於電子速度為離子速度的數千倍,撞擊物體表面而被吸收的機率遠大於離子.



Neutrals

$m = 6.6 \quad 10^{-23} g$

$T = 20^{\circ}C = 293K \equiv 1/40eV$

$\bar{c} = 4.0 \quad 10^{4}$ cm/sec

Ions

$m_i = 6.6 \quad 10^{-23} g$

$T_i = 500K \equiv 0.04eV$

$\bar{c}_i = 5.2 \quad 10^{4}$ cm/sec

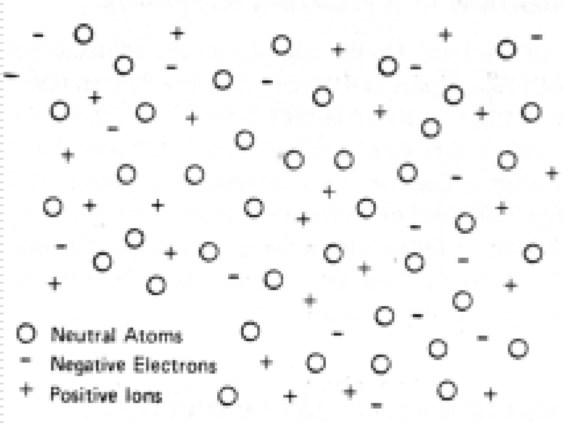
Electrons

$m_e = 9.1 \quad 10^{-28} g$

$T_e = 23\,200K \equiv 2eV$

$\bar{c}_e = 9.5 \quad 10^{7}$ cm/sec

$$\bar{c} = \left(\frac{8kT}{\pi m}\right)^{1/2}$$



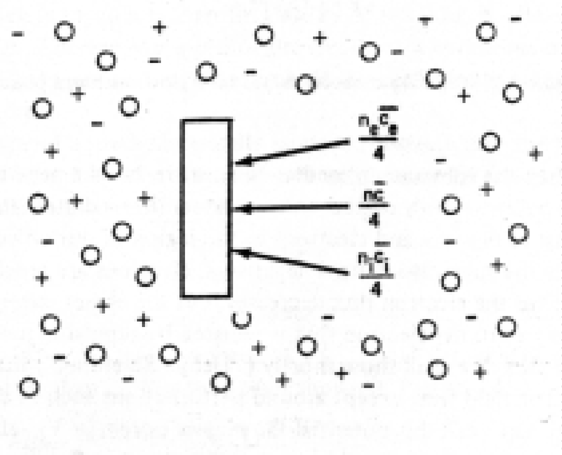
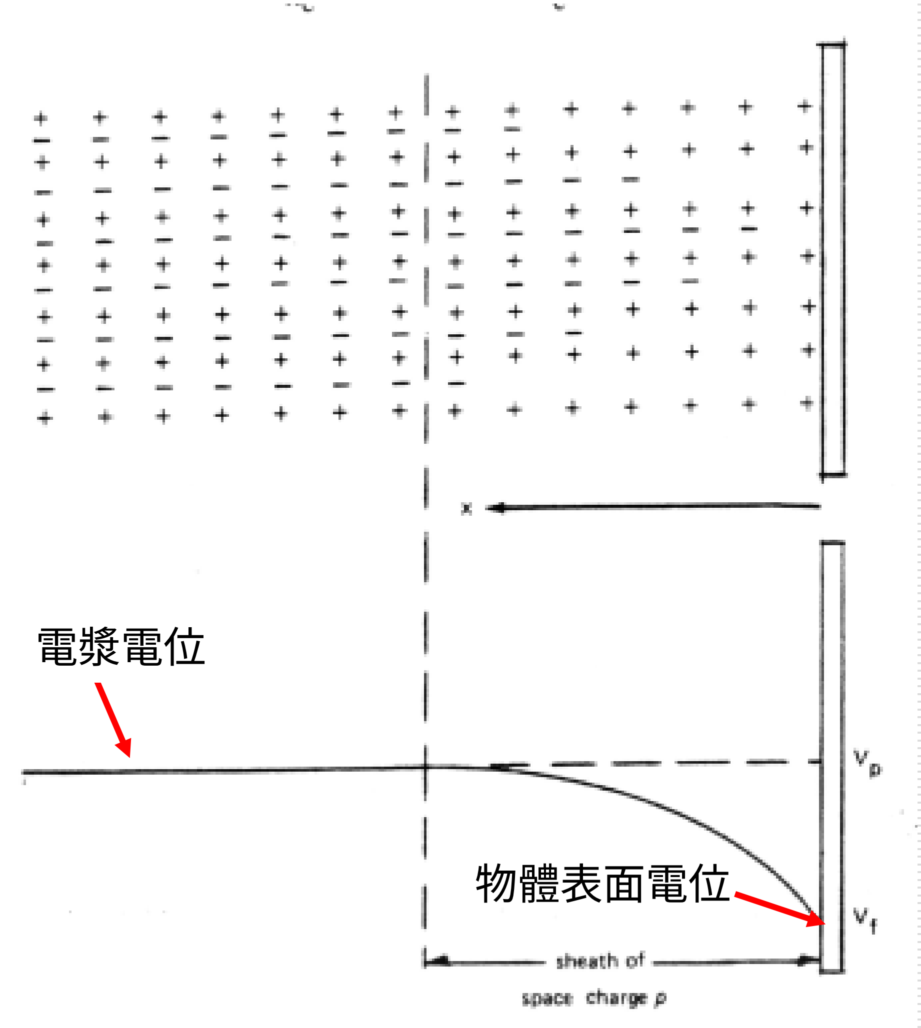


Figure 3-3. Initial particle fluxes at the substrate

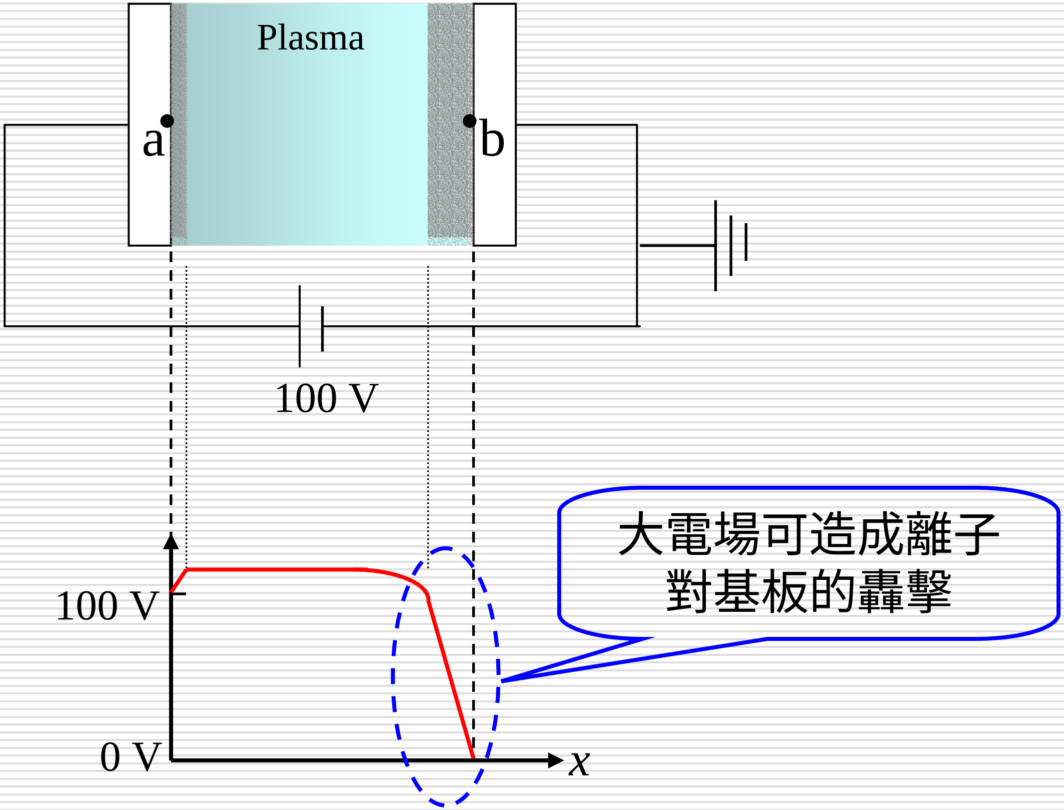
- Plasma potential (電漿電位)

因此物體表面聚集較多電子,而表面附近則有一充滿正離子之區域.此現象造成物體表面電位低於電漿電位.

為何電極表面附近會有一暗區？

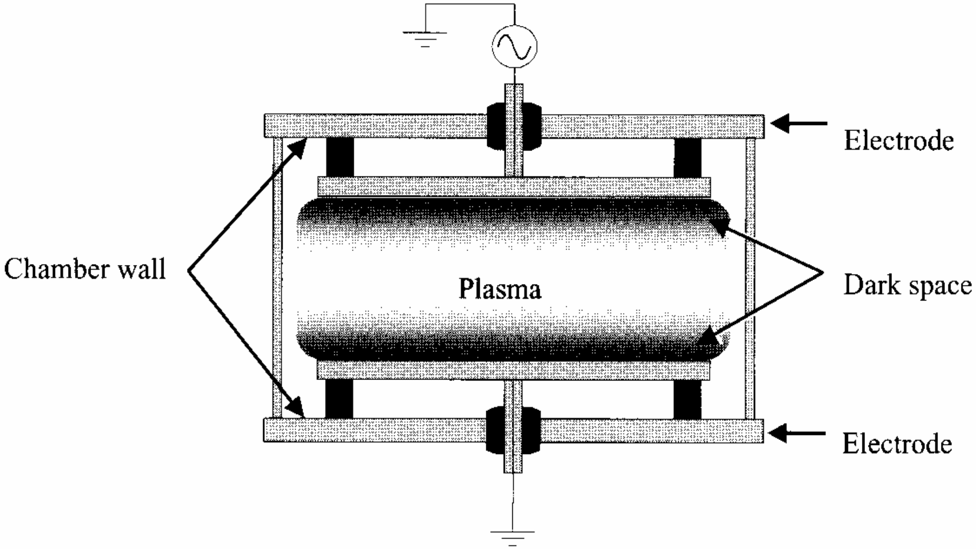


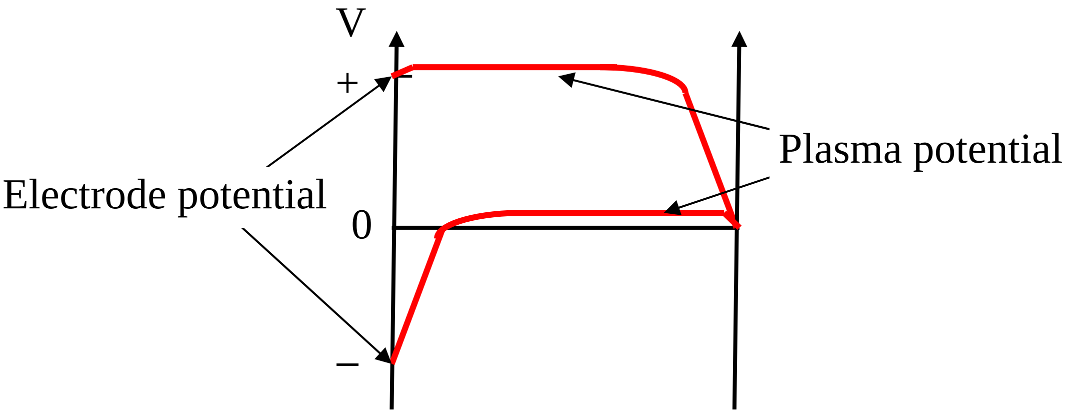
- DC plasma
  - 請畫出下圖電漿形成後a點至b點之電位變化圖



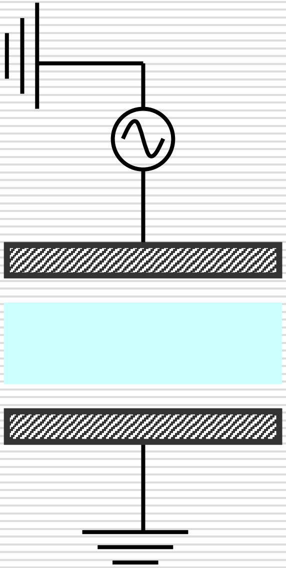
大電場可造成離子對基板的轟擊

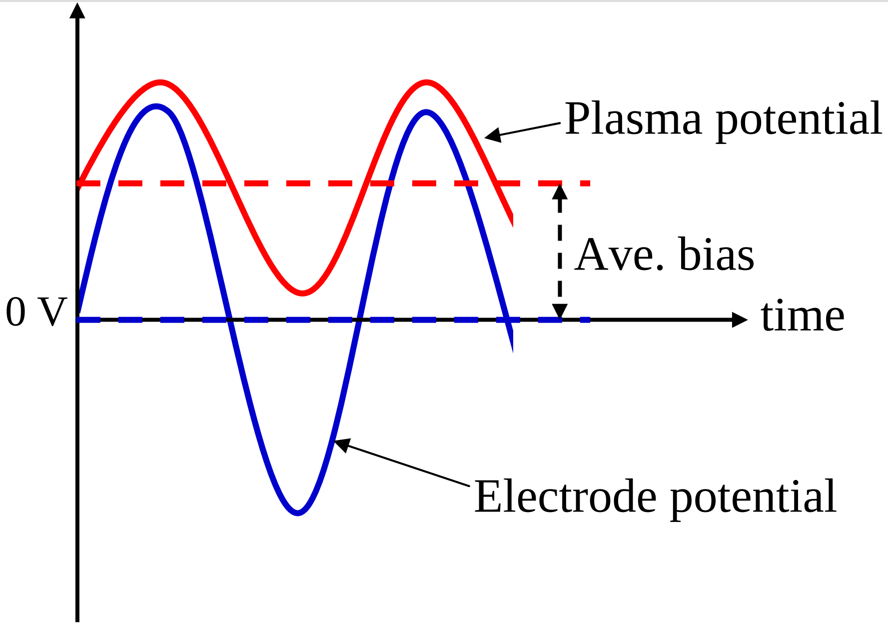
- RF plasma


Electrode
Chamber wall
Plasma
Dark space
Electrode

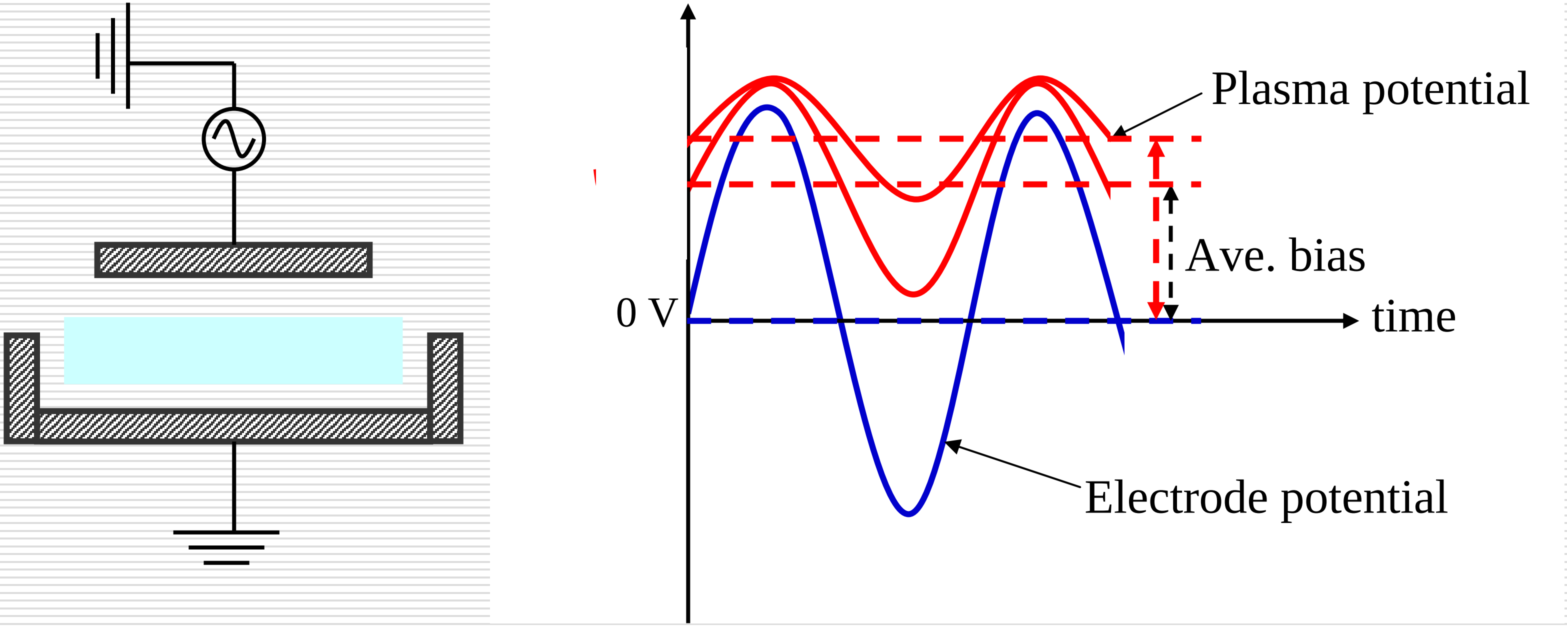

V
+
Plasma potential
Electrode potential
0
–

- RF plasma





電極大小對電漿電位之影響



- Plasma power supply 之配置

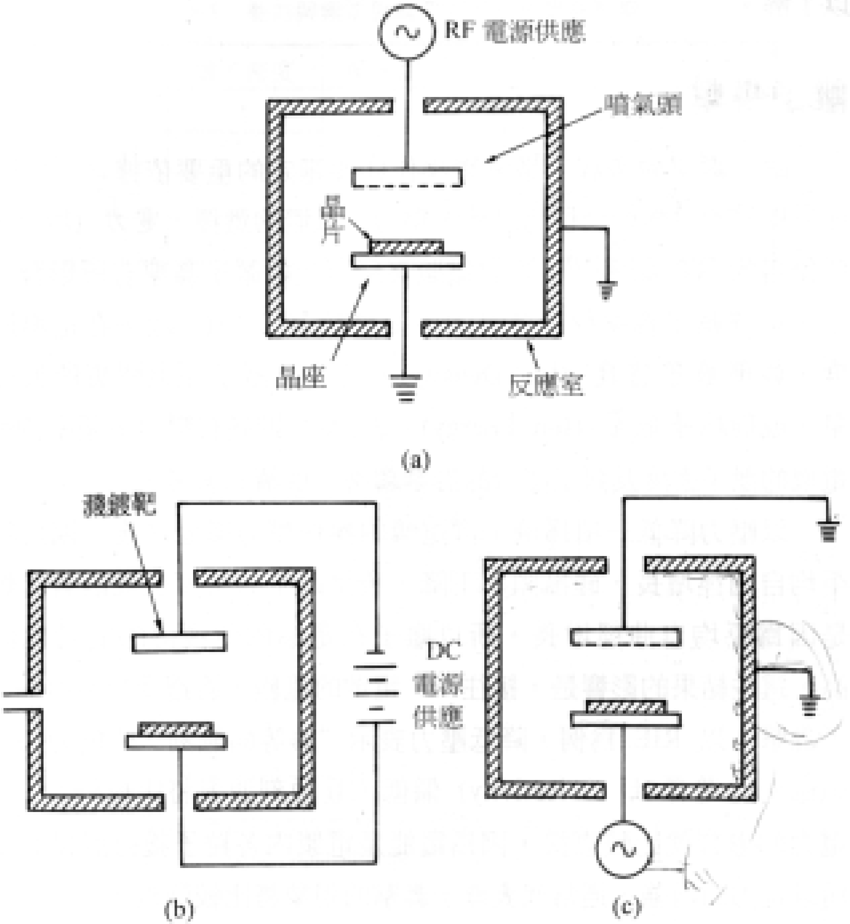


圖 A-10 顯示三種主要的電漿反應裝置的應用。(a) 常見於 PECVD；(b) 常見於 DC 金屬濺鍍；而 (c) 則常見於乾蝕刻。

2.2.1 PECVD

- PECVD reactions

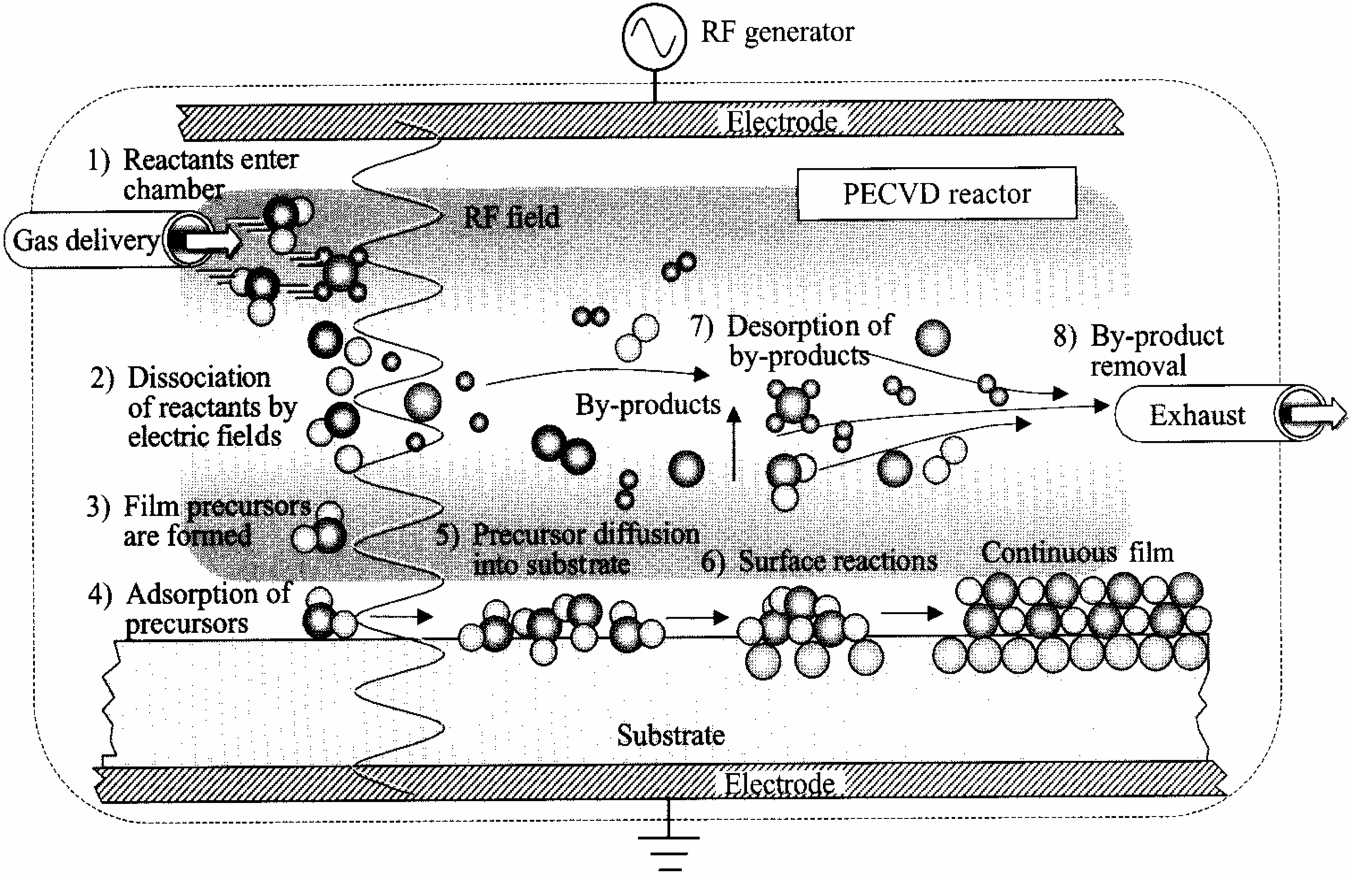


FIGURE 11.19 Film Formation During Plasma-Assisted CVD

- PECVD equipments

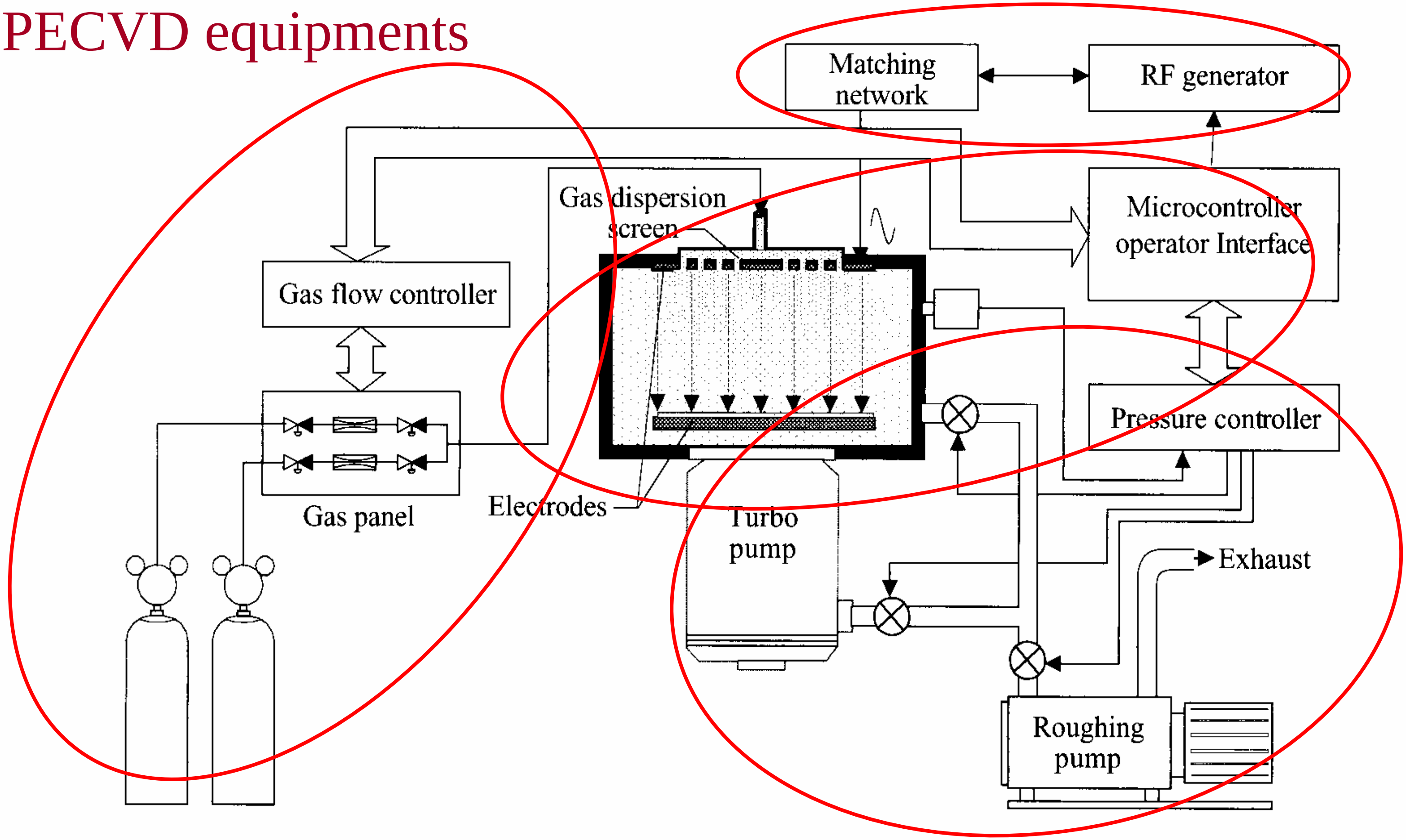
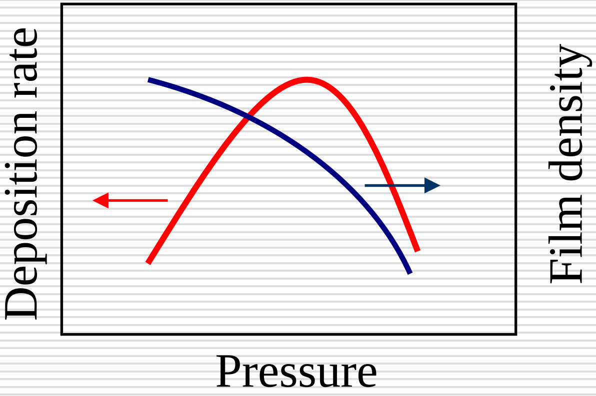


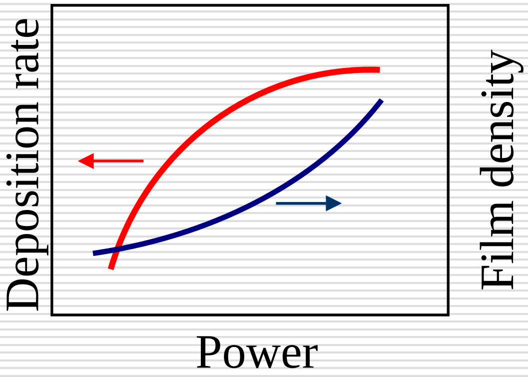
FIGURE 11.20 General Schematic of PECVD

• PECVD 製程參數效應

主要影響因子:

1) 反應壓力
2) 電漿功率
3) 基板溫度
4) 氣體流量比





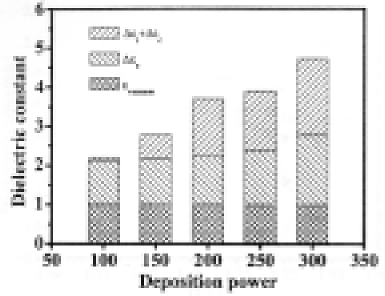


Fig. 5-2 : Dielectric constant of the a-C:H films prepared with deposition power from 100 to 300 W.