Química Si-F: efeito de adição de O_2

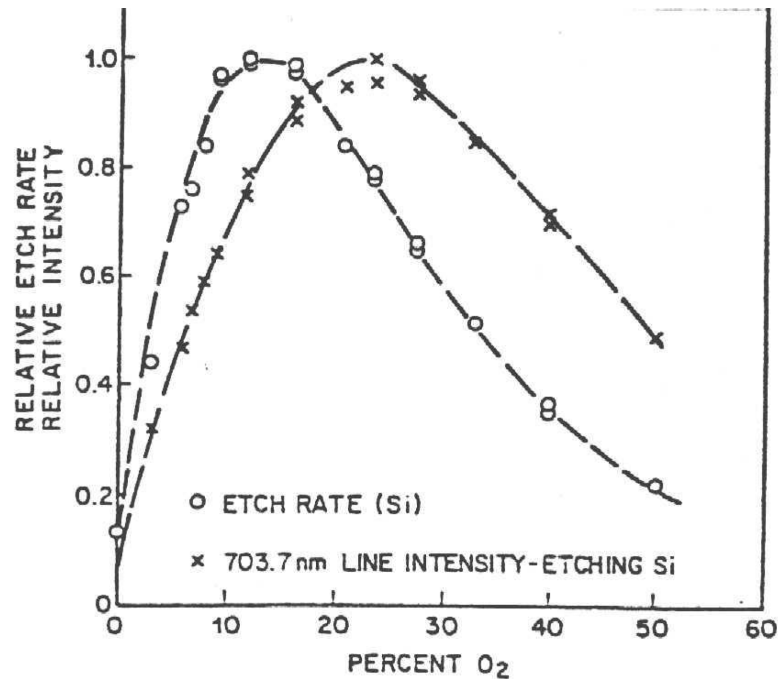


Fig. 8 The normalized etch rate for Si and the normalized intensity of the emission from electronically excited F atoms (703.7 nm line) versus the O_2 concentration in the CF_4-O_2 etch gas[4]. Reprinted with permission of the American Physical Society.

Corrosão de Si com carbofluoretos: corrosão vs. polimerização, como função de razão F/C

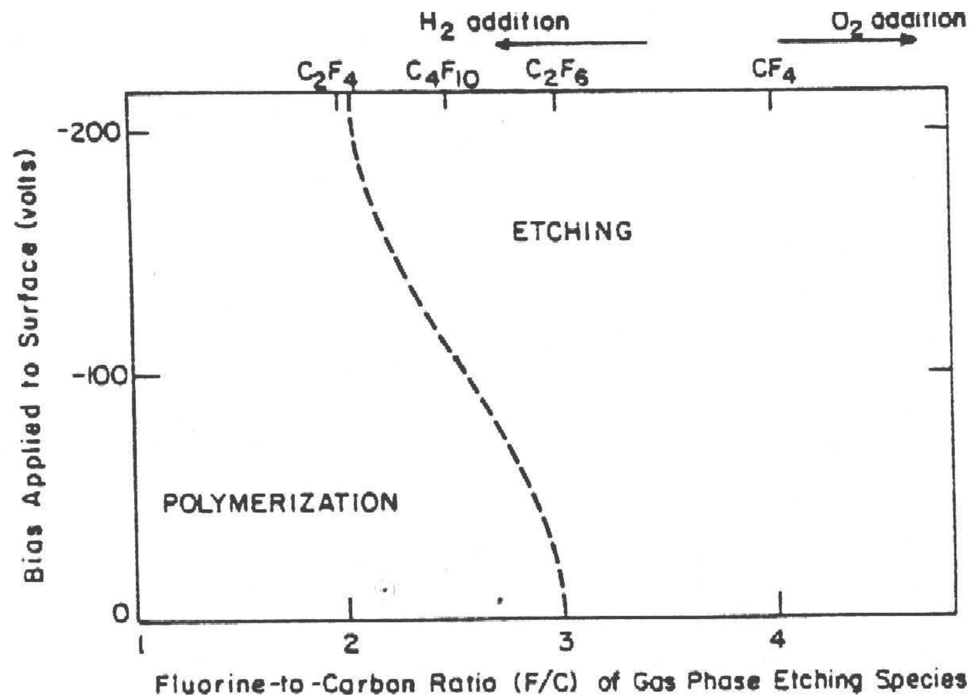


Fig. 10 Illustrative plot of the boundary between polymerizing and etching conditions as influenced by the fluorine-to-carbon ratio of the chemically reactive species and the bias applied to a surface in the discharge[10]. Reprinted with permission of the American Physical Society.

CF_4/H_2: seletividade de corrosão Si/SiO_2

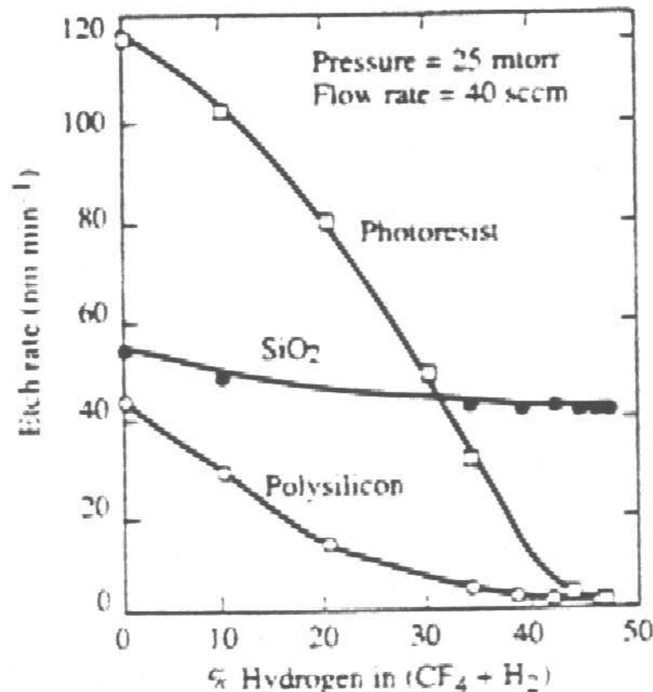


Figure 10–25 The etch rates of Si and SiO_2 (and photoresist) as H_2 is added to a CF_4 gas mixture. (After [10.15].)

Adição de H_2 $\Rightarrow$ aumenta polimerização, o que

• diminui a taxa de corrosão de Si (dificultando transporte dos reagentes e dos produtos de corrosão),

• mas quase não afeta a taxa de corrosão de SiO_2 (a presença do filme de carbofluoretos na superfície de óxido é favorável para corrosão dele, através das reações $C + n\,O \rightarrow CO, CO_2\uparrow$ (n=1,2)

$$SiF_x + m\,F \rightarrow SiF_4\uparrow$$

Corrosão de Si e fotorresiste em misturas contendo Cl e F

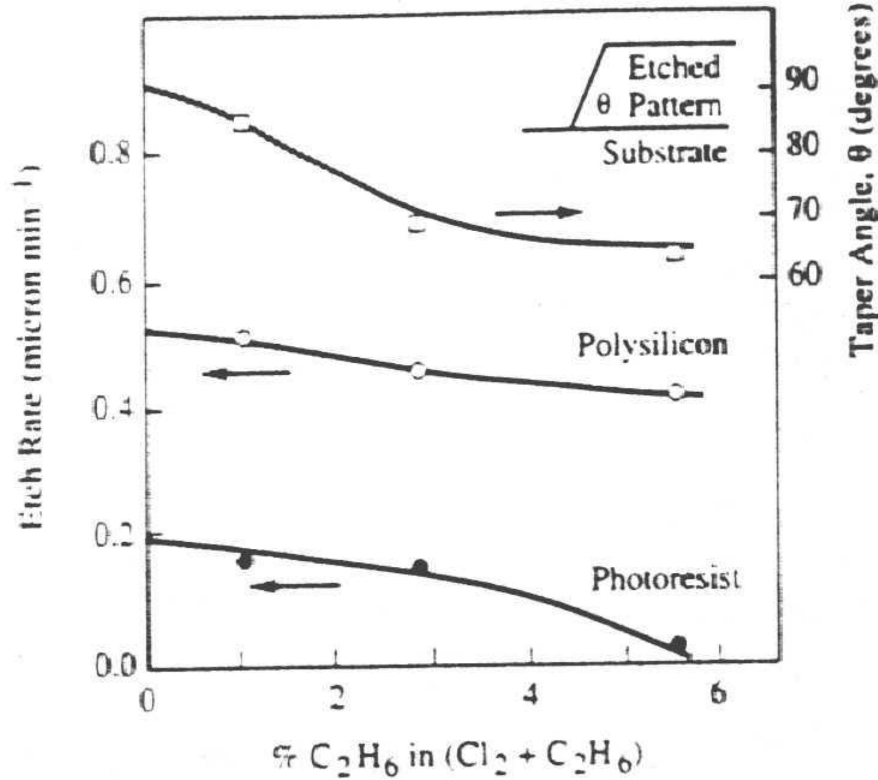
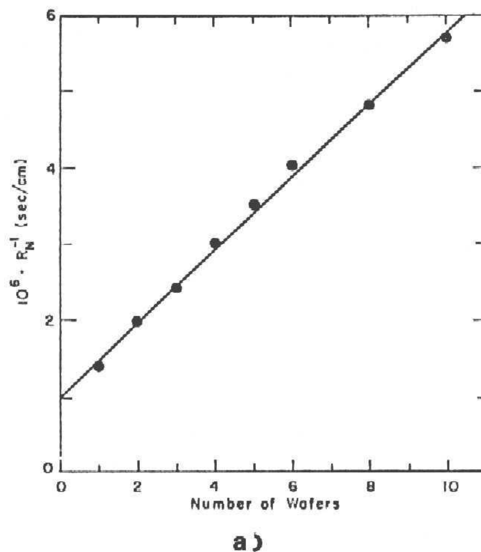
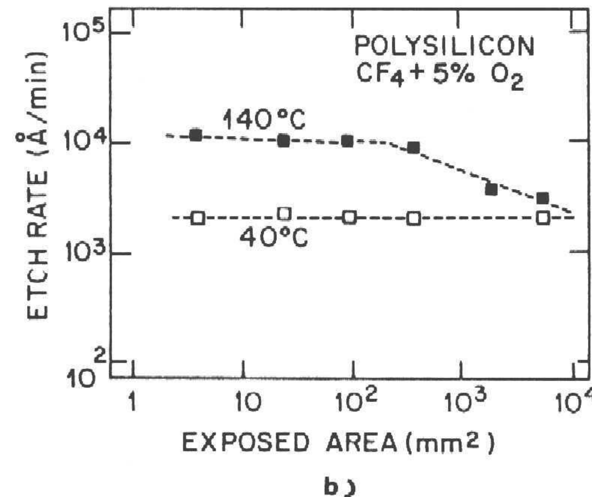


Figure 10–21 Etch rate of polysilicon and photoresist, and resulting taper angle as a function of C_2H_6 in Cl_2/C_2H_6 etch chemistry. More C_2H_6 results in more sidewall inhibitor formation and deposition relative to etching. (After [10.8].)

Loading effect (a taxa de corrosão depende da área corroída)





Origem do efeito: escassez de átomos de F que estão sendo consumidos em reação com Si

Fig. 31 (a) Reciprocal of Si etch rate vs. number of 3" wafers, demonstrating the loading effect[65]. Reprinted with permission of the publisher, the Electrochemical Society. (b) The etch rate of Si is increased sufficiently and /or the reactivity is increased sufficiently by increasing temperature[66]. Reprinted with permission of the Japanese Journal of Applied Physics.

Rugosidade de corrosão

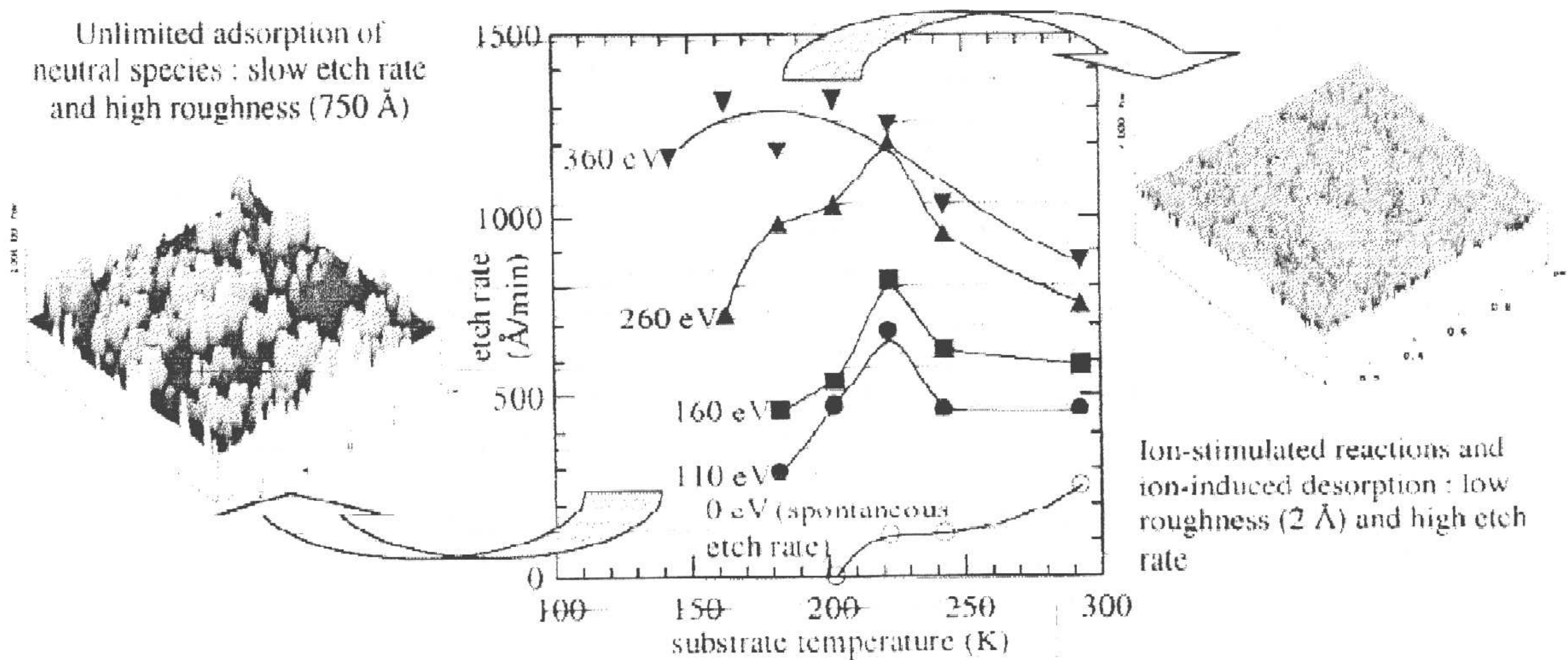


Fig. 4. Influence of surface temperature and ion energy on etch rate and surface roughness.

Ruptura de estruturas finas no final de corrosão de porta de transistor MOS

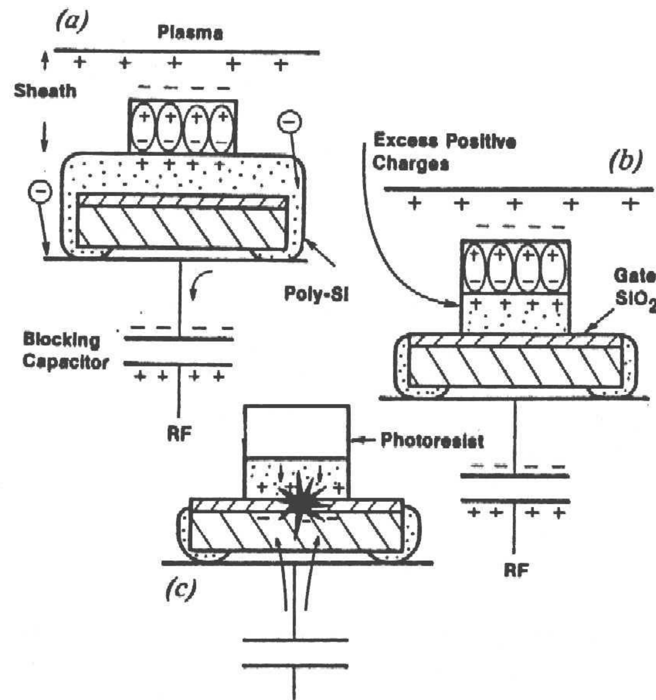


Fig. 32 Gate oxide breakdown[70]. Reprinted with permission of Solid State Technology, published by Technical Publishing, a company of Dun & Bradstreet.

Diagnóstico de plasmas reativos (*end point*): espectroscopia óptica de emissão

Table 3. SPECIES and EMISSION WAVELENGTH for OPTICAL EMISSION END POINT DETECTION[50]

FILM	SPECIES MONITORED	WAVELENGTH (NM)
Resist	CO	297.7, 483.5, 519.8
	OH	308.9
	H	656.3
Silicon, Polysilicon	F	704
	SiF	777
Silicon Nitride	F	704
	CN	387
	N	674
Aluminum	AlCl	261.4
	Al	396

Diagnóstico de plasmas reativos (*end point*):

espectroscopia óptica e reflectometria

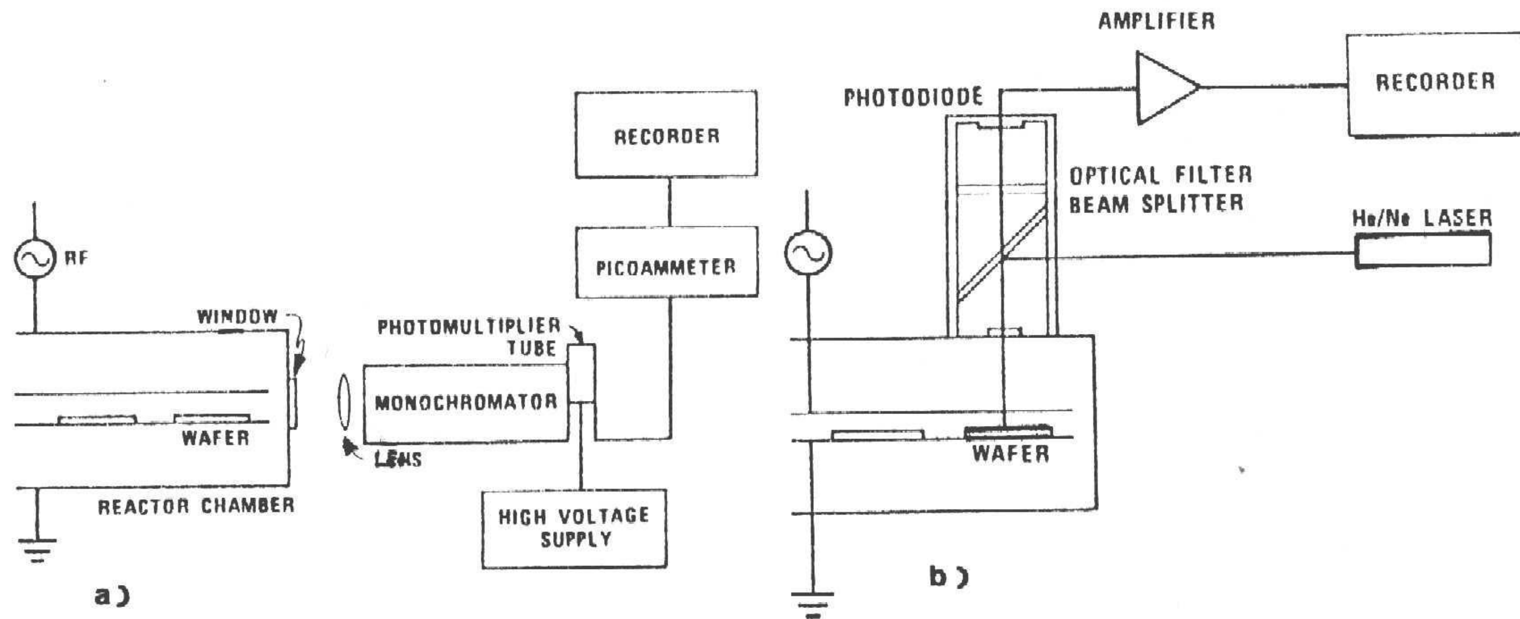


Fig. 24 (a) Experimental apparatus for using emission spectroscopy as an end point detector; (b) Typical apparatus for the optical reflection method of end point detection[50]. Reprinted by permission of Solid State Technology, published by Technical Publishing, company of Dun & Bradstreet.

Diagnóstico de plasmas reativos (*end point*): espectrometria de massas

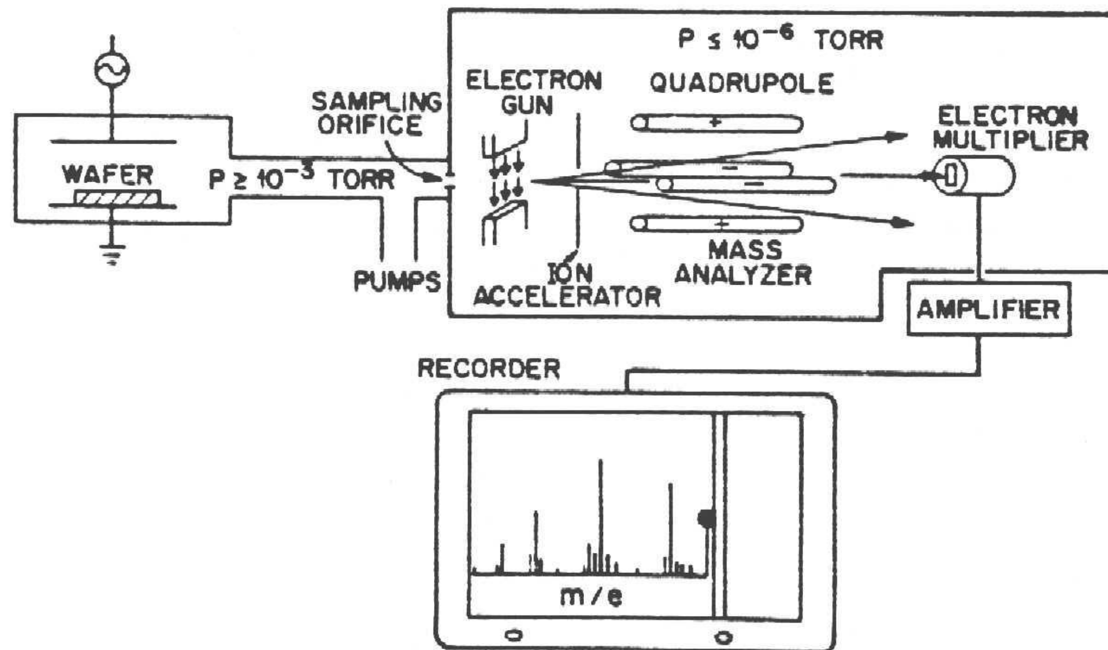


Fig. 25 Diagram for mass spectrometric monitoring of effluents from a plasma etching reactor. Reprinted with permission of Ref. 1, copyright, 1983, the American Chemical Soc.

Reatores de plasma: plasma remoto e barril

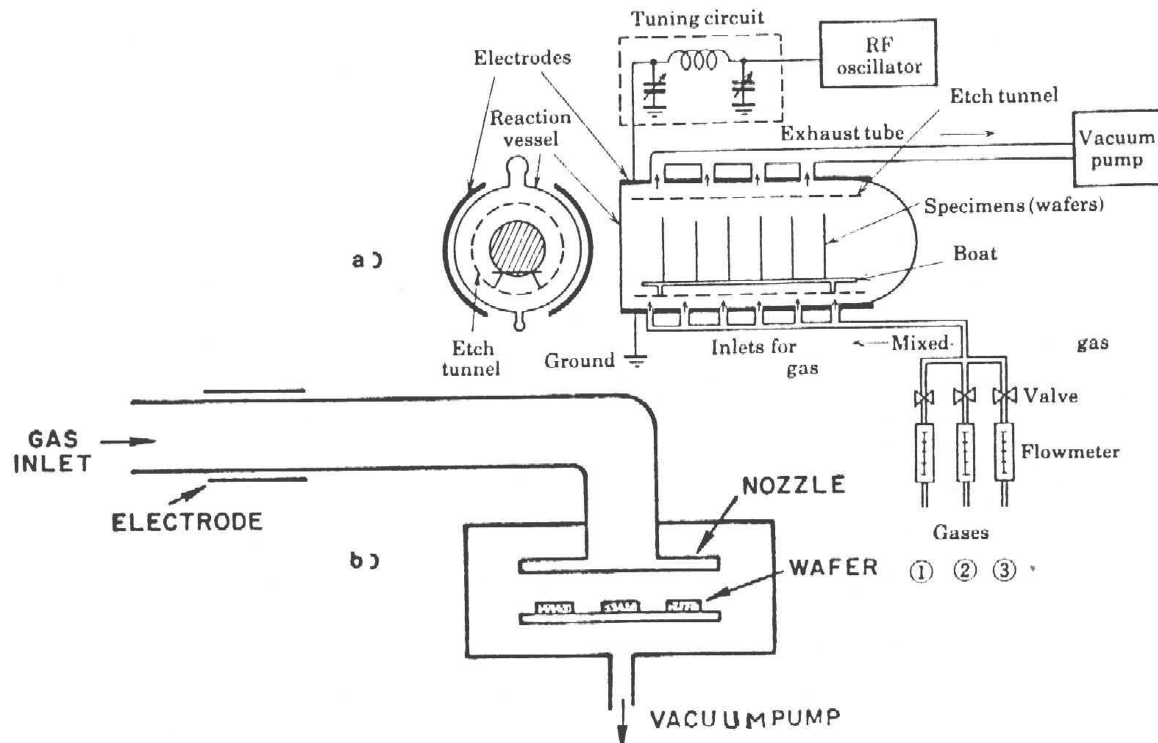


Fig. 26 Schematic of: (a) a barrel-type plasma etching system. (b) a downstream plasma etcher.

Reatores de plasmas planares:
plasma etching vs. *reactive ion etching*

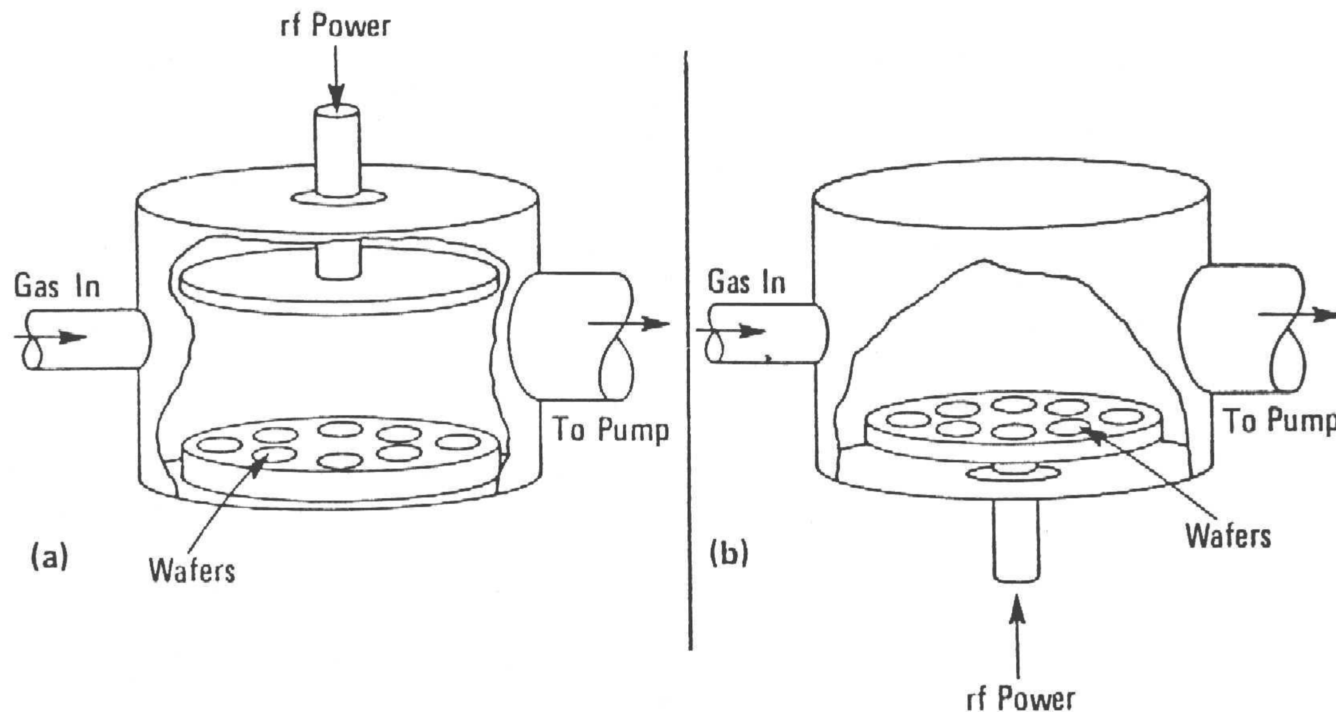


Fig. 27 Parallel-electrode (planar) type dry etcher. (a) When wafers are placed on the grounded electrode, the system is configured in the plasma etch mode. (b) When wafers are placed on the powered electrode, the system is operated in the reactive ion etch, or RIE, mode.

Reator planar RF : distribuição de potencial

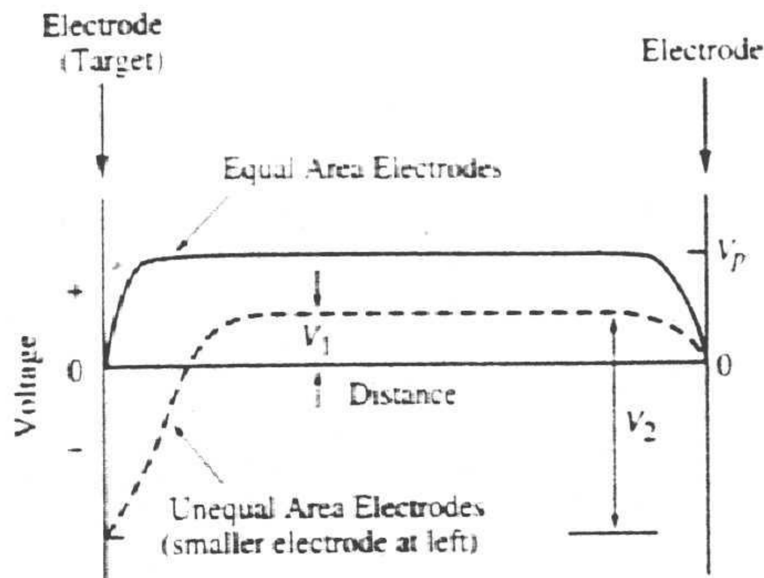
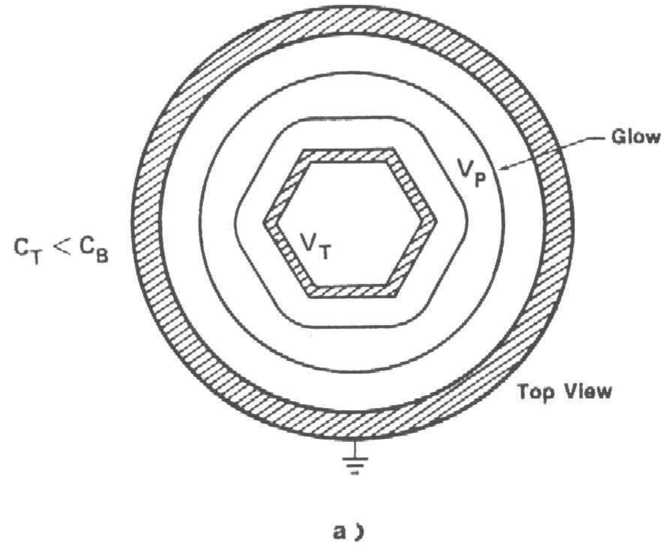
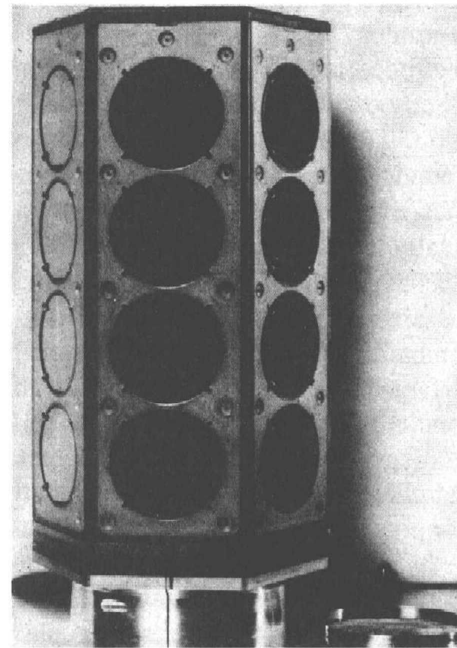


Figure 10–8 Steady-state voltage distribution in RF-powered plasma etch systems. (See Figure 9–27 and the associated text for a more complete discussion of this figure.)

Reator industrial RF (RIE) , configuração do hexodo





b)

Fig. 29 (a) Schematic of the electrode configuration of the hexode batch etcher. (b) Photograph of a hexode batch etcher. Courtesy of Applied Materials.