Ciência e Tecnologia de Filmes Finos

- Tecnologia de Vácuo

Posmat 2011

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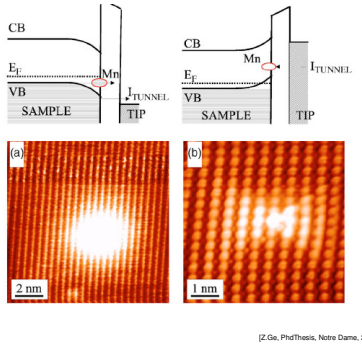
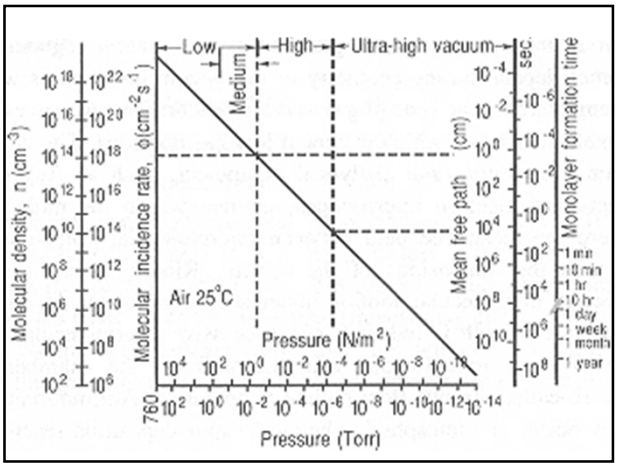
Motivação para estudar tecnologia de vácuo

- 1. Obtenção de filmes mais puros!
- 2. Deposição molécula a molécula



[Z.Ge, PhdThesis, Notre Dame, 2007]



Ciência e Tecnologia de Filmes Finos

- Tecnologia de Vácuo
  - Sistemas de bombeamento/bombas
  - Câmaras de vácuo / vedações
  - Medidores de pressão e analisadores de gases
  - Equações do bombeamento
  - Exercícios

Por que vácuo?

Exemplos:

contaminação em filmes

tempo de formação de monocamada

Tecnologia de Vácuo

- por que vácuo ?
- como produzir e usar vácuo ?
- quais as faixas de pressões de trabalho?
- quais as tecnologias de vácuo disponíveis atualmente?

Tecnologia de Vácuo

-como produzir vácuo ?

... do mais simples ...

... ao mais sofisticado....

5-axis control The STP600, STP1000, STP2001 and all the high throughput pumps (H-C), utilise a full 5 active axis system with electromagnets for all bearings. This patented, fully active system allows an automatic balancing system to be used.

Sistemas de bombeamento

- **Tipos de bombas**

- qual faixa de pressão de trabalho te interessa ?

Esquema geral de sistemas de vácuo

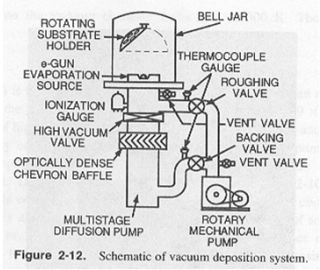
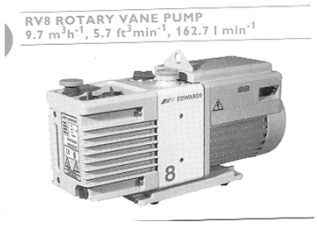
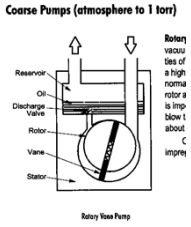


Figure 2-12. Schematic of vacuum deposition system.

Baixo vácuo

- Gerando pressões entre a atmosférica e ~ 10^{-2} torr (1Pa) baixo vácuo
- Bombas mecânicas (rotativas)





Bomba mecânica – palhetas rotativas

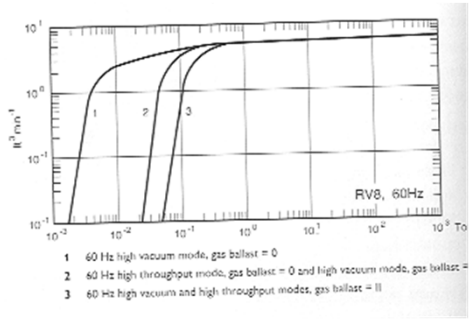
Bomba Mecânica – Velocidade de Bombeamento

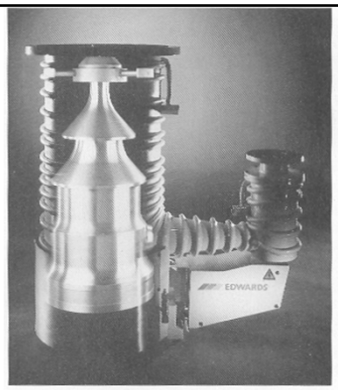
TECHNICAL DATA

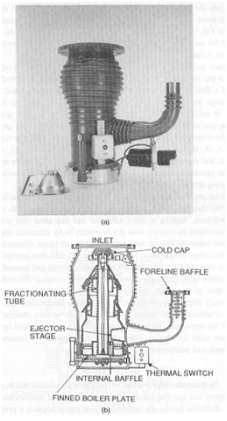
Displacement	
50 Hz operation	9.7 m^3h^{-1} / 5.7 ft^3min^{-1}
60 Hz operation	11.7 m^3h^{-1} / 6.9 ft^3min^{-1}

Bomba Mecânica – Palhetas rotativas

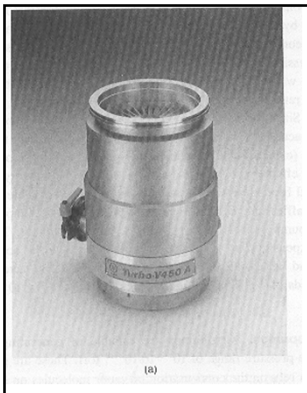
Velocidade de bombeamento x Pressão

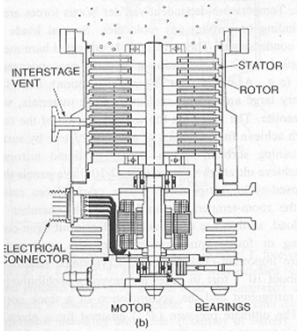






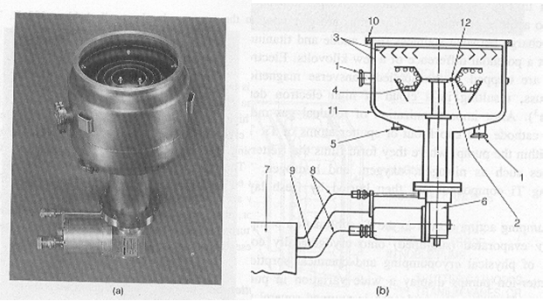
Bombas difusoras



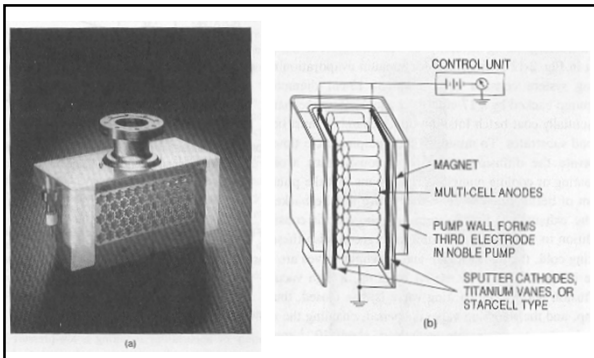


Como funciona ?

Bombas Turbo-Moleculares

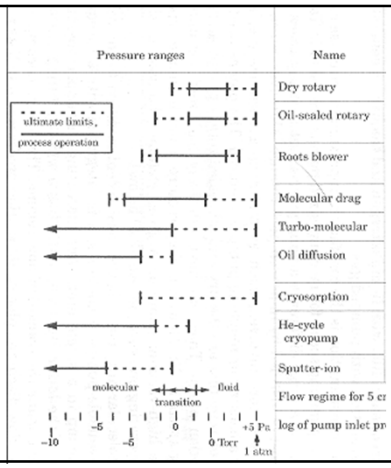


- **Bombas criogênicas e de sorção**



- **Bombas iônicas e de sublimação**

- Alguma pergunta até aqui?



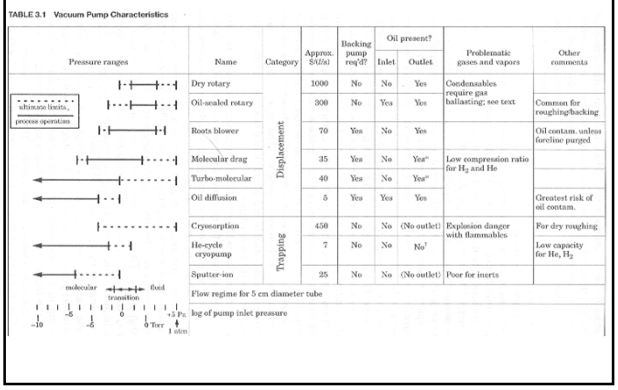


TABLE 3.1 Vacuum Pump Characteristics

Pressure ranges	Name	Category	Approx. $/kl/s)	Backing pump req'd?	Oil present? Inlet	Oil present? Outlet	Problematic gases and vapors	Other comments
	Dry rotary	Displacement	1000	No	No	Yes	Condensables require gas ballasting; see text	
ultimate limits, process operation	Oil-sealed rotary		300	No	Yes	Yes		Common for roughing/backing
	Roots blower		70	Yes	No	Yes		Oil contam. unless foreline purged
	Molecular drag		35	Yes	No	Yes[a]	Low compression ratio for H_2 and He	
	Turbo-molecular		40	Yes	No	Yes[a]		
	Oil diffusion		5	Yes	Yes	Yes		Greatest risk of oil contam.
	Cryosorption	Trapping	450	No	No	(No outlet)	Explosion danger with flammables	For dry roughing
	He-cycle cryopump		7	No	No	No[b]		Low capacity for He, H_2
	Sputter-ion		25	No	No	(No outlet)	Poor for inerts	
molecular transition fluid	Flow regime for 5 cm diameter tube							
−10 −5 −5 0 Torr +5 Pa 1 atm	log of pump inlet pressure							

Resumindo:

Cada tipo de bomba é adequada para uma determinada faixa de pressões

Os sistemas de vácuo devem ser pensados pela pressão final e pela quantidade de fluido bombeado !

Sistemas de Bombeamento (Fim)

Equações do Bombeamento

Final Sistemas de Bombeamento!
Prox. Equações do Bombeamento

Equações do Bombeamento de Gases

Exemplo:

Determinação prática da velocidade de bombeamento da evaporadora flash

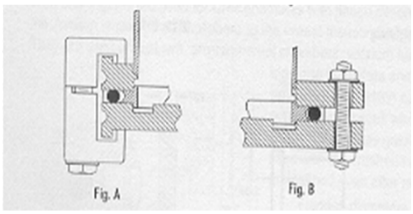
Medidores de Pressão

Exemplo:

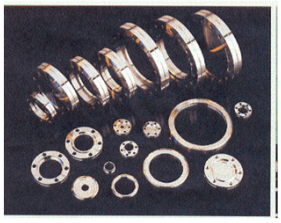
Analisador de Gases Residuais (RGA)

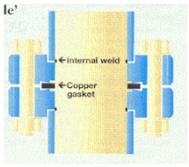
Formas de Vedação a Vácuo

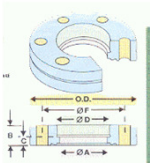
Baixo e alto vácuo (760 a 10^{-5} torr) selo de borracha (O´ring)



Ultra alto vácuo (UHV, p ~ 10^{-6} – 10^{-11} torr)







Selo metálico – Anéis de cobre (CONFLAT)

- Alguma pergunta até aqui?

Exercícios Cap. 3

3.4
3.6
3.8
3.10
3.12

3.4 A process chamber of 1 m^2 surface area is outgassing at a rate of 10^{13} mo/cm^2 s. For a process-gas flow of 200 sccm and a total pressure of 100 Pa, what is the partial pressure of the outgassing impurities?

3.5 List the advantages of N_2 purging of pumping systems.

3.6 What are the pump choices for a process operating at 10^{-2} Pa, and what are the relative advantages and disadvantages of each?

3.7 A pump foreline 5 cm in diameter and 300 cm long is being purged with Ar. (a) How many sccm of Ar flow are required to attenuate the pump-oil partial pressure by 10^{10} over the length of the tube? (b) What will be the total pressure, p, at the upstream end if the pumping speed is such that p at the downstream end is 50 Pa?

3.8 Suppose that the inside surface of an Al vacuum chamber is coated with 100 nm of poorly formed anodic oxide having 20 percent porosity consisting of 2-nm-diameter cylindrical pores. (a) What is the ratio of the total internal surface area of the pores to the macroscopic area of the Al surface? (b) If two monolayers of water are adsorbed on all of the internal surface area, how many scc are adsorbed per m^2 of macroscopic area?

3.10 Water diffusing through an elastomer O-ring seal from atmosphere at a rate of 0.01 sccm is the principal background gas in a particular vacuum chamber being pumped at 1000 l/s. What is the partial pressure, in Pa, of water in the chamber?

3.11 An ion gauge which indicates pressures p_i is being calibrated against a capacitance diaphragm gauge which indicates pressures p_c and which has a zero offset of p_o. The following three data points (p_i, p_c) are taken, in units of Pa: (0.12, 0.04), (0.10, 0.03), and (0.06, 0.01). (a) What is p_o? (b) What is the ion gauge calibration factor $f = p_c/p_i$?

3.12 List the factors affecting the level of water background in a vacuum chamber.

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