Tecnologia de Vácuo

Aula 05 – 2019
Prof. Humberto
Unesp / Posmat

3. Tecnologia de Vácuo

3.0 Introdução

3.1 (a) Bombas de Vácuo
3.1 (b) Vedações

3.2 (a) Medidores de Pressão
3.2 (b) Analisadores de gases
3.2 (c) Regimes de escoamento

3.3 (a) Medidores de Fluxo
3.3 (b) Vazão e veloc. de bombeamento
3.3 (c) Experimento e Exercícios – Cap. 3

- **por que vácuo ?**

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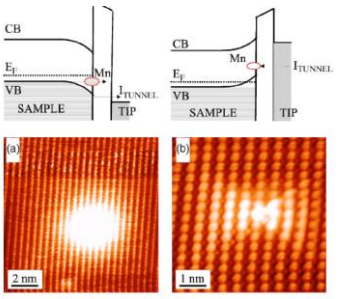
Aplicação STM



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

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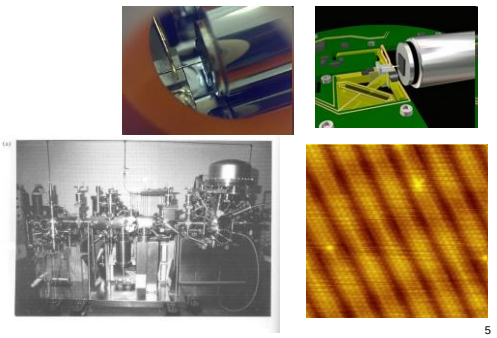
STM – microscópio de tunelamento



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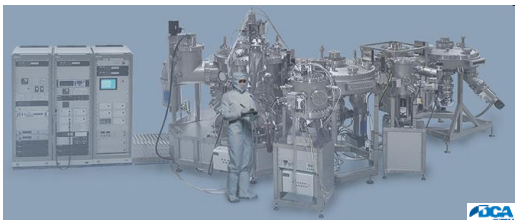
Sistema de MBE (Epitaxia por Feixe Molecular)



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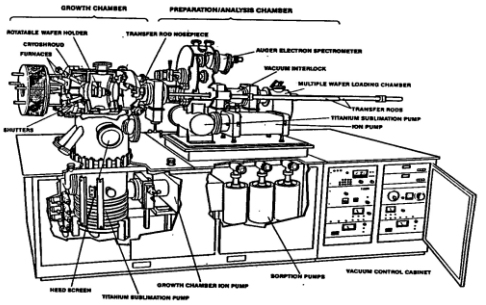
Sistema de MBE



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Outras aplicações

- Microscopias eletrônicas
- Caracterização em baixa temperatura (criostatos).
- Espectroscopia UV
- XPS – UPS
- Processamento de materiais bulk de alta pureza

P: por que vácuo ?

R:

Fundamental para:

- interação molécula <=> superfície
- superfície “limpa”
- alta pureza (=> semicondutores)

Exemplo anterior MBE:

$p \sim 10^{-10}$ torr / 1 μm/h

=> $2x10^{18}$ impurezas/cm^3 (~dopagem)

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Nível de vácuo - classificação

Classification	Vacuum Level [a], [b], [c], [d]	
	Pa	Torr
Low (“rough”) Vacuum	133.3 to 1.33×10^{-1}	1 to 1×10^{-3}
Medium (“intermediate”) Vacuum	$<1.33 \times 10^{-1}$ to 1.33×10^{-3}	$< 1 \times 10^{-3}$ to 10^{-5}
High (“HV”) Vacuum	$<1.33 \times 10^{-3}$ to 1.33×10^{-6}	$< 1 \times 10^{-5}$ to 10^{-8}
Ultrahigh (“UHV”) Vacuum	$<1 \times 10^{-7}$ to 1×10^{-8}	7.5×10^{-10} to 7.5×10^{-11}
Extreme Ultrahigh Vacuum	$< 1 \times 10^{-10}$	$< 7.5 \times 10^{-13}$
Interstellar Space	10^{-17}	7.5×10^{-20}

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Motivação para estudar tecnologia de vácuo

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

- **Sistemas de deposição de filmes**
  - **exemplos**

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Sistema de evaporação

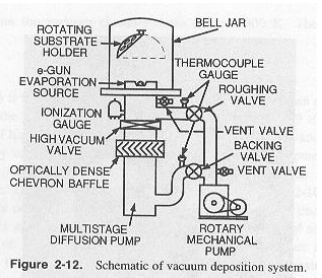
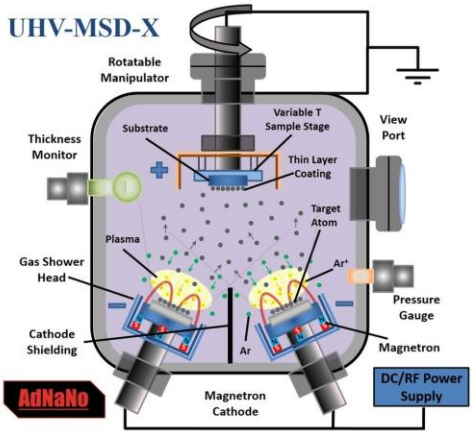
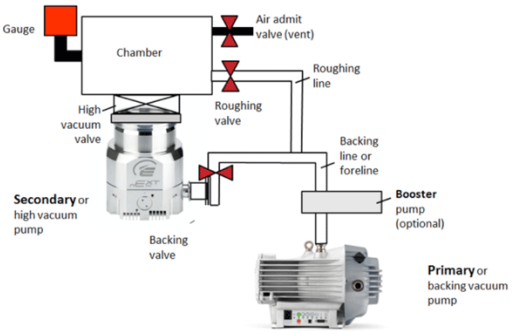
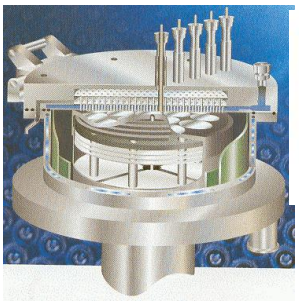


Figure 2-12. Schematic of vacuum deposition system.





Reator CVD complexo (comercial)



- **como produzir vácuo ?**

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Tecnologia de Vácuo

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

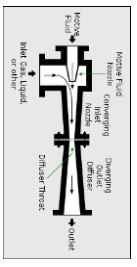
Tecnologia de Vácuo

- **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....

STP MAGNETICALLY LEVITATED TURBOMOLECULAR PUMPS

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.

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Sistemas de bombeamento

- **Tipos de bombas**

- qual faixa de pressão de trabalho te interessa ?

Esquema geral de sistemas de vácuo

câmara de evaporação

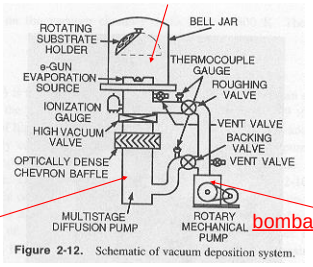


Figure 2-12. Schematic of vacuum deposition system.

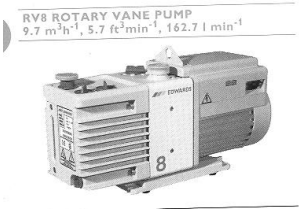
bomba difusora

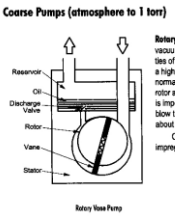
bomba mecânica

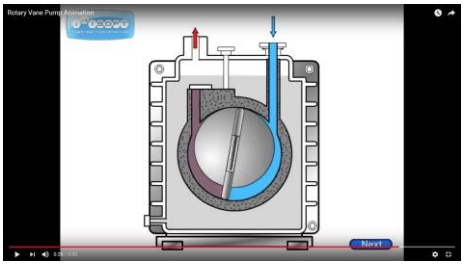
Baixo vácuo

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

https://www.youtube.com/watch?v=AFHogF-9eGA







Bomba mecânica – palhetas rotativas

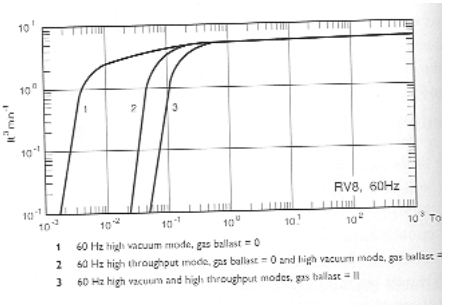
Bomba Mecânica – Velocidade de Bombeamento

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}

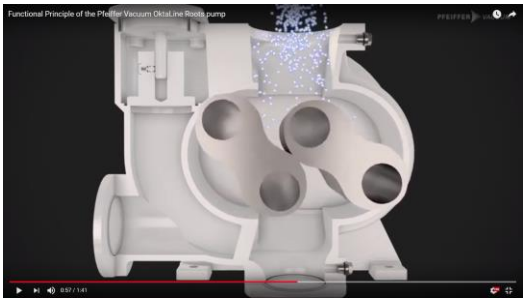
Bomba Mecânica – Palhetas rotativas

Velocidade de bombeamento x Pressão



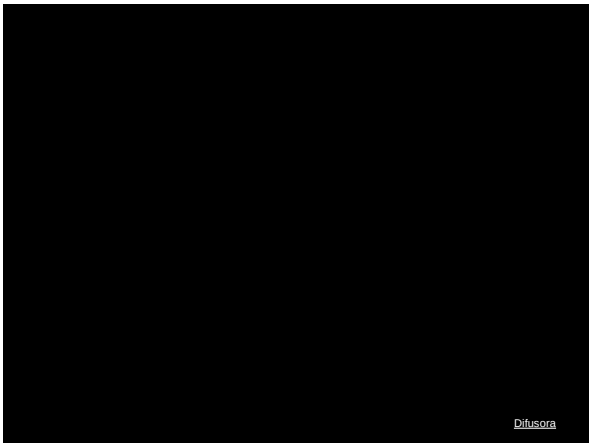
Bomba Roots

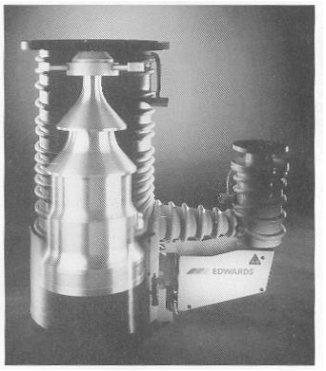
https://www.youtube.com/watch?v=aAeilhp_Gog

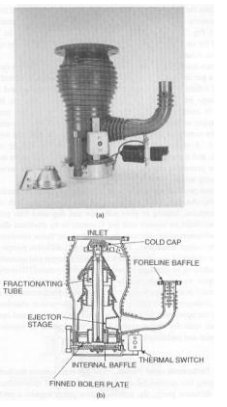


https://www.agilent.com/en/video/agilent-idp-dry-scroll-pump-family

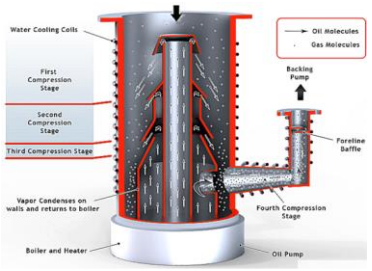
Bomba scroll

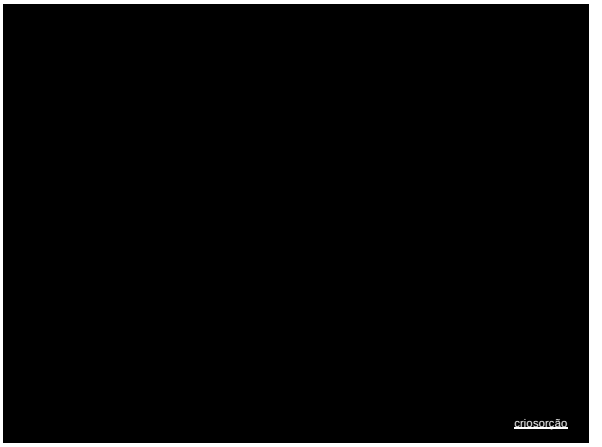


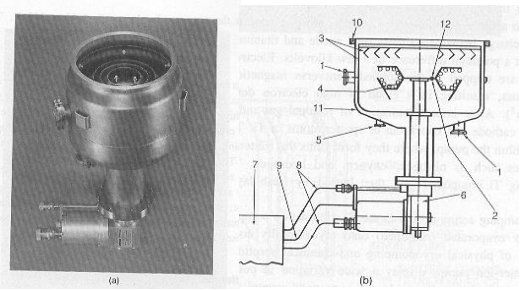




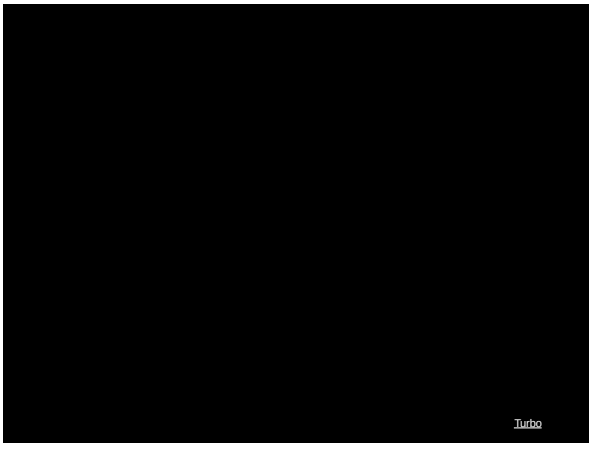
Bombas difusoras

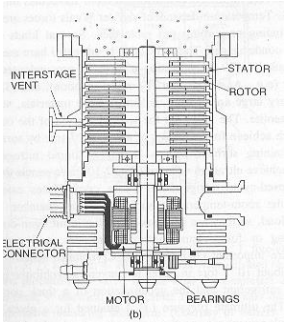






- **Bombas criogênicas e de sorção**





Como funciona ?

https://www.youtube.com/watch?v=A0v3tNCLqkA

Bombas Turbo-Moleculares

STP MAGNETICALLY LEVITATED TURBOMOLECULAR PUMPS

... ao mais sofisticado....

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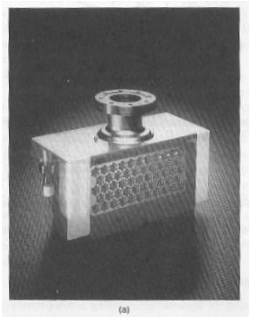

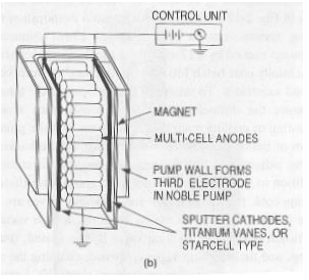

- **Bombas iônicas e de sublimação**

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Bomba iônica – células múltiplas

[redacted]

- Alguma pergunta até aqui?

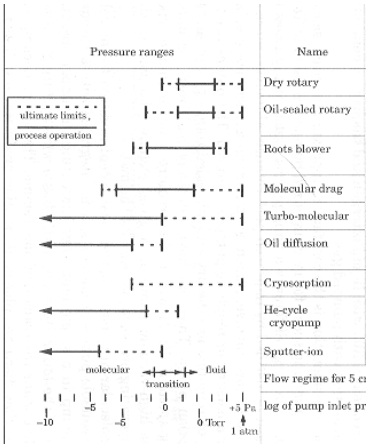


TABLE 3.1 Vacuum Pump Characteristics

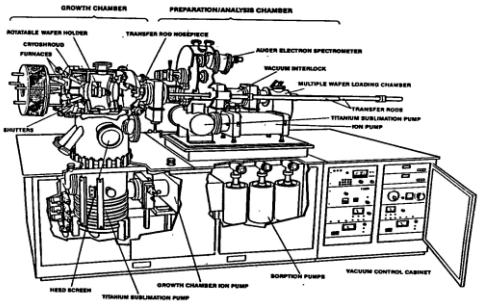
Pressure ranges	Name	Category	Approx. S (l/s)	Backing pump req'd?	Oil present? Inlet	Oil present? Outlet	Problematic gases and vapors	Other comments
ultimate limits, process operation	Dry rotary	Displacement	1000	No	No	Yes	Condensables require gas ballasting; see text	
	Oil-sealed rotary		300	No	Yes	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 !

Sistema de MBE



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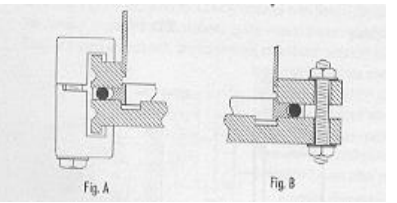
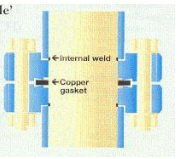
Final Bombas
Formas de Vedação

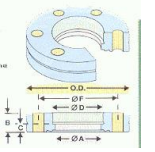
Formas de Vedação a Vácuo

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

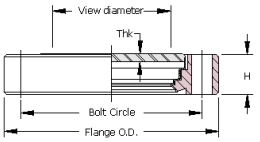


Ultra alto vácuo
(UHV, p ~ 10^{-6} – 10^{-11} torr)





Selo metálico – Anéis de cobre
(CONFLAT)



- Perguntas ?

Próximos temas -

- Medidores de pressão
- Analisadores de gases
- Regimes de escoamento
- Medidores de Fluxo
- Vazão e velocidade de bombeamento

=> ir para slides 3.2