

Ciência e Tecnologia de Filmes Finos 2011

•A Técnica de MBE

Como produzir interfaces e
camadas finas, com alta pureza e
controle?

2

Como crescer tantas camadas e
com tal precisão ?

Epitaxia por Feixe Molecular (MBE)

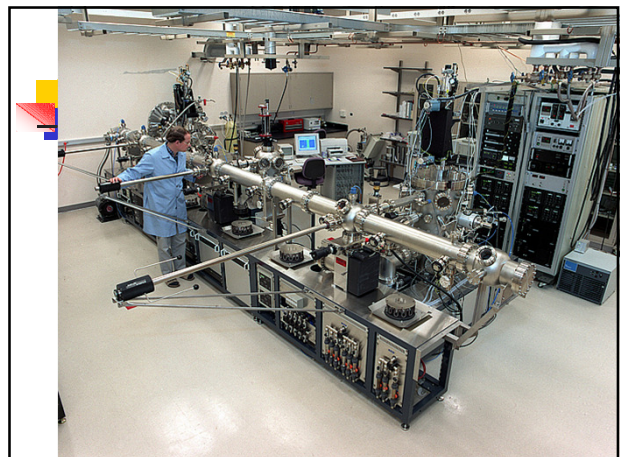
3

MBE

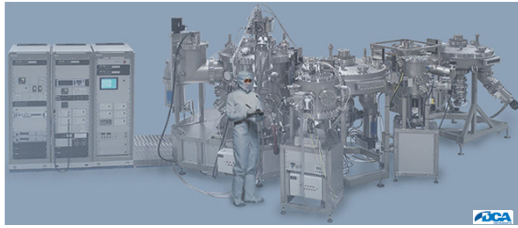
Características

Caracterização "in-situ":
REED (difração de elétrons)
XPS-UPS
Pressão residual $< 10^{-10}$ torr
Alto controle de $T_{\text{substrato}}$
Excelente contr. das células de
efusão
Transferência de substr. em vácuo

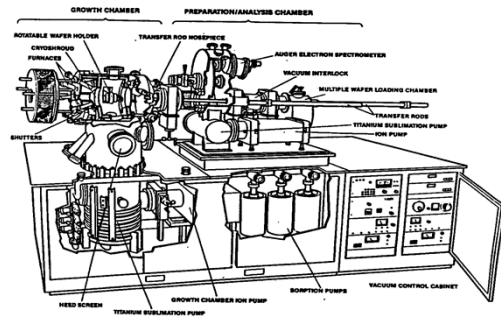
Propaganda comercial
de MBE =>



Produção de MQW-LEDs e LASERS: várias etapas – em vácuo



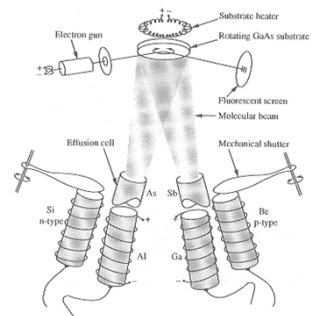
Sistema de MBE



MBE

- Controle
- SIMPLICIDADE ?!!!!?

9

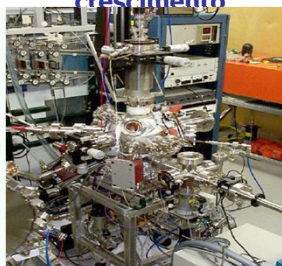
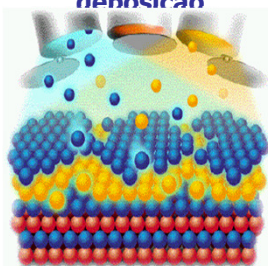


Esquema: Deposição M.B.E.

Epitaxia MBE

Simulação de densidade

Câmara de crescimento



11

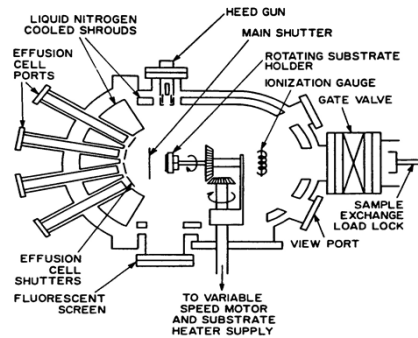


Figure 6. Schematic of a typical MBE growth chamber (top view). (Courtesy A. Y. Cho, AT&T Bell Laboratories.)

Componentes essenciais da técnica de MBE

- Células de Efusão / Fontes
- Substratos / Epitaxia
- Caracterização "in situ"
- Vácuo

13

Células de Efusão – (Knudsen)

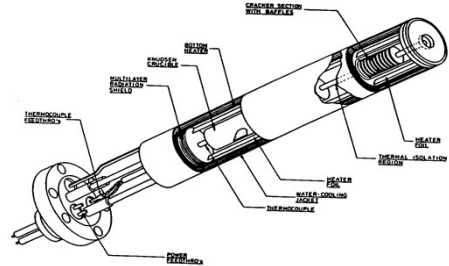


Figure 8. Conventional high temperature As cracker effusion cell consisting of a low temperature sublimation and high temperature cracking zone. (From Ref. 9.)

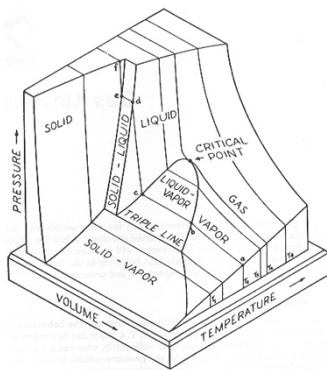


Figure 2.1 p-V-T diagram for a fixed amount of pure material. (Reprinted from Sears (1950) with permission of the publisher. © 1950, 1953 by Addison-Wesley Publishing)

Porta substratos com temperatura controlada / baixa P_{vapor}

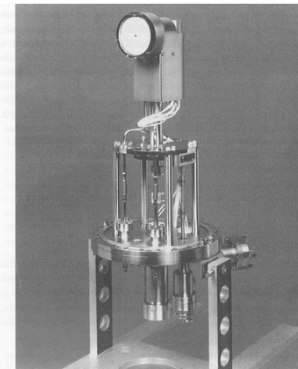


Figure 12. Substrate holder, showing substrate mounting pins and springs, thermocouple, PEN heat diffusion disk, CAR mechanism, thermocouple and heater wires and feed-throughs and manipulator.

Vácuo
/formação de monocamada
/pressão residual

17

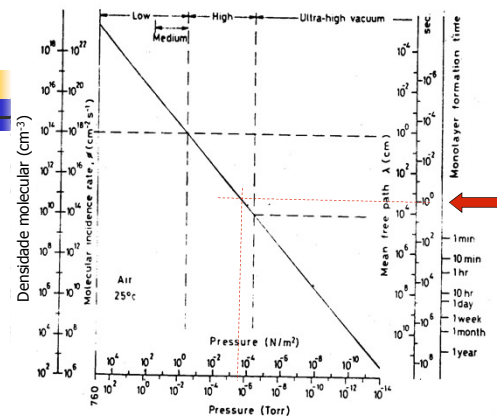


Fig. 1.1 Relationship of several concepts defining the degree of vacuum.

18

Epitaxia por Feixe Molecular (MBE)

Caracterização das camadas em crescimento

Caracterização in Situ
- Difração de elétrons durante o crescimento

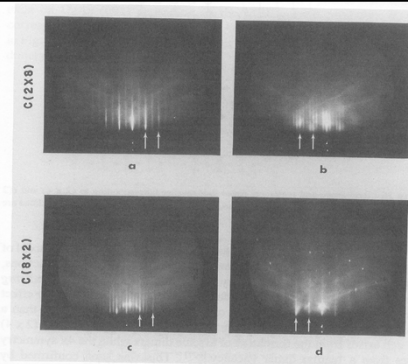


Figure 15. RHEED patterns obtained by 15 keV electron beam from GaAs (001) surface: c(2 x 8) As-stabilized reconstruction and c(8 x 2) Ga-stabilized reconstruction as obtained in [110] azimuth (a and c) and [-110] azimuth (b and d). The arrows indicated the position of bulk-like (unreconstructed) streaks. (Courtesy A. J. Cho, AT&T Bell Laboratories.)

Caracterização in Situ
- Difração de elétrons durante o crescimento

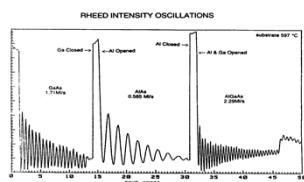


Figure 19. RHEED intensity oscillations during growth of GaAs, AlAs, and AlGaAs.

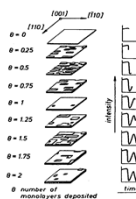


Figure 20. Representation of the formation of the first two monolayers of GaAs (001) leading to RHEED intensity oscillations. (After Fig. 152.)

Ciência e Tecnologia de Filmes Finos –
POSMAT/2011
Prof. José Humberto Dias da Silva