Interaction hydrogen plasma and a-Si:H thin film

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Hydrogen role

Processing aspects

Fundamental role in a-Si:H and μc-Si:H deposition, etching, surface passivation, chemical annealing,…

In solar cells

Hydrogen affects the SnO_2, the P-layer, and the P/I interface.

In-situ study of hydrogen diffusion in a-Si:H by SE

- a-Si:H is deposited by PECVD
- Reactor CAMELEON
- In-situ measurements by UV-visible ellipsometry
- Ex-situ measurements by SIMS

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Effects of hydrogen plasma

Etching

Clean walls

PECVD, HWCVD,

H SiH_4

a-Si:H

Substrate

Chemical transport

a-Si:H coated walls

PECVD, HWCVD,

SiH_4 H

SiH_3

Substrate

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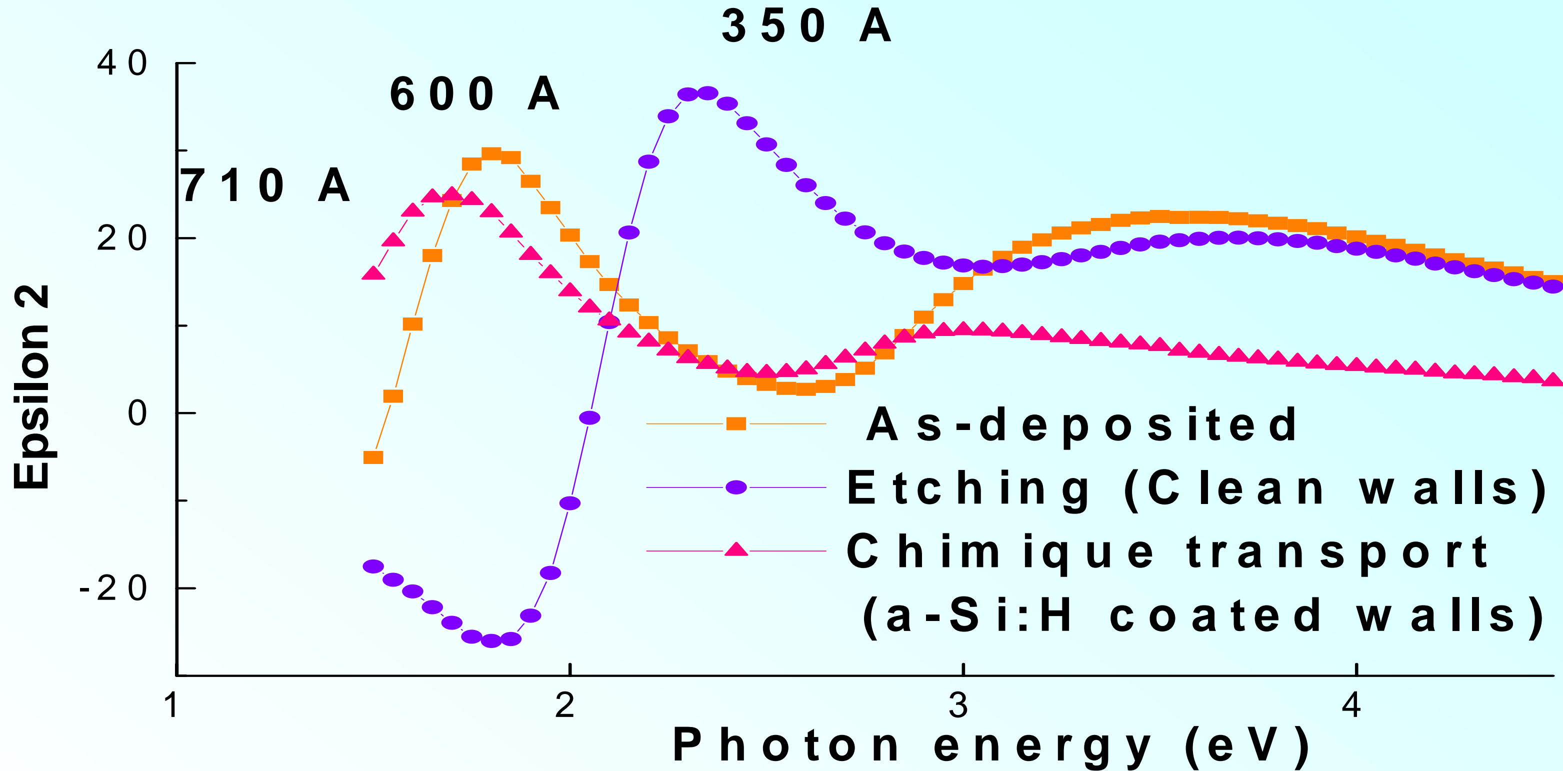
N-type a-Si:H exposed for 10 minutes to a hydrogen plasma

250 sccm, 1 torr, 250°C, 30W



The Shift of interference fringes → High energy → Etching

The Shift of interference fringes → Low energy → Chemical transport

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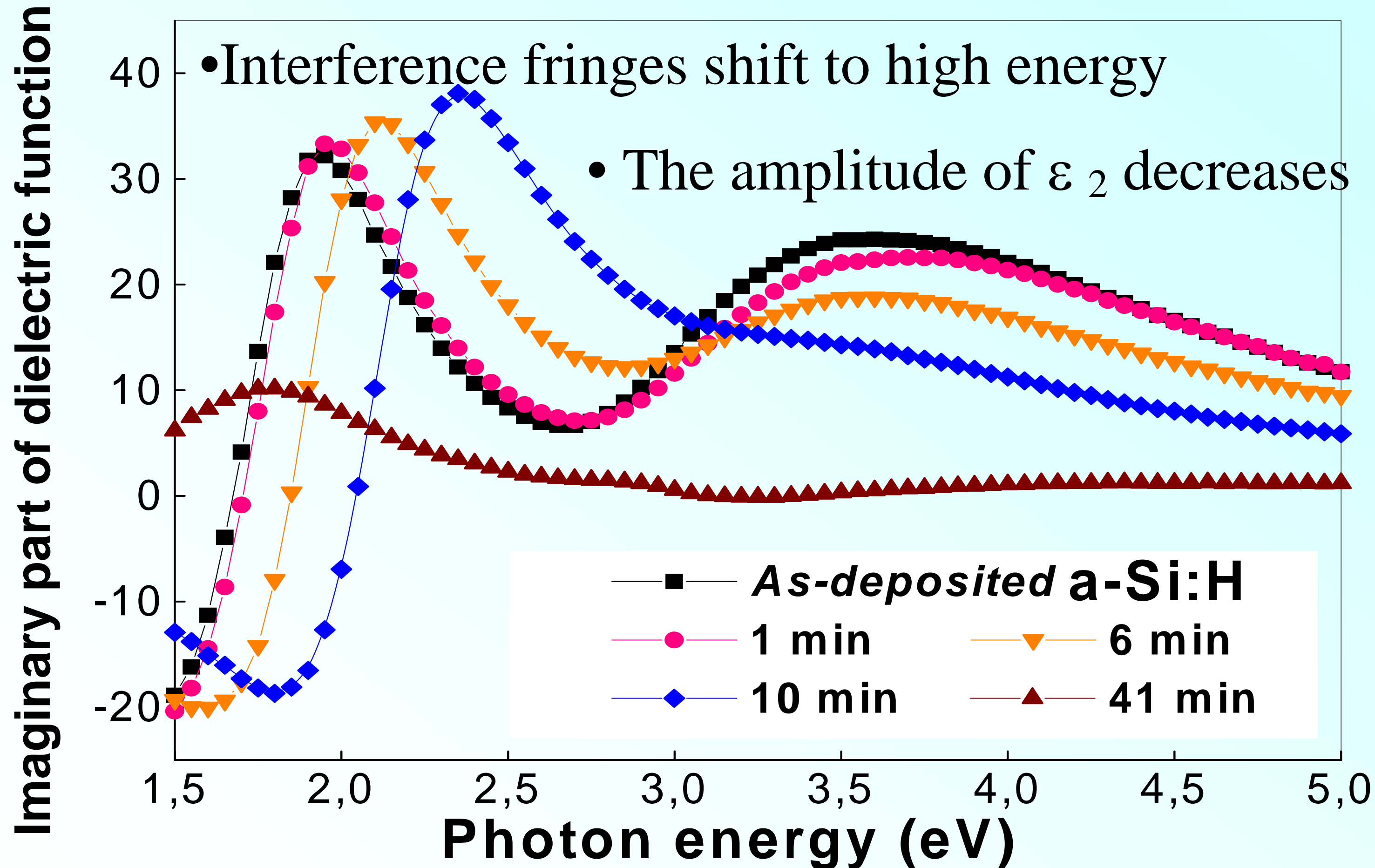
I. Etching of Intrinsic a-Si:H

a-Si:H deposition : **P = 60 mtorr, P_{rf} = 3 W, T_s = 230°C.**

H_2 Plasma : **P = 1 torr, P_{rf} = 22 W, Ts = 230°C.**



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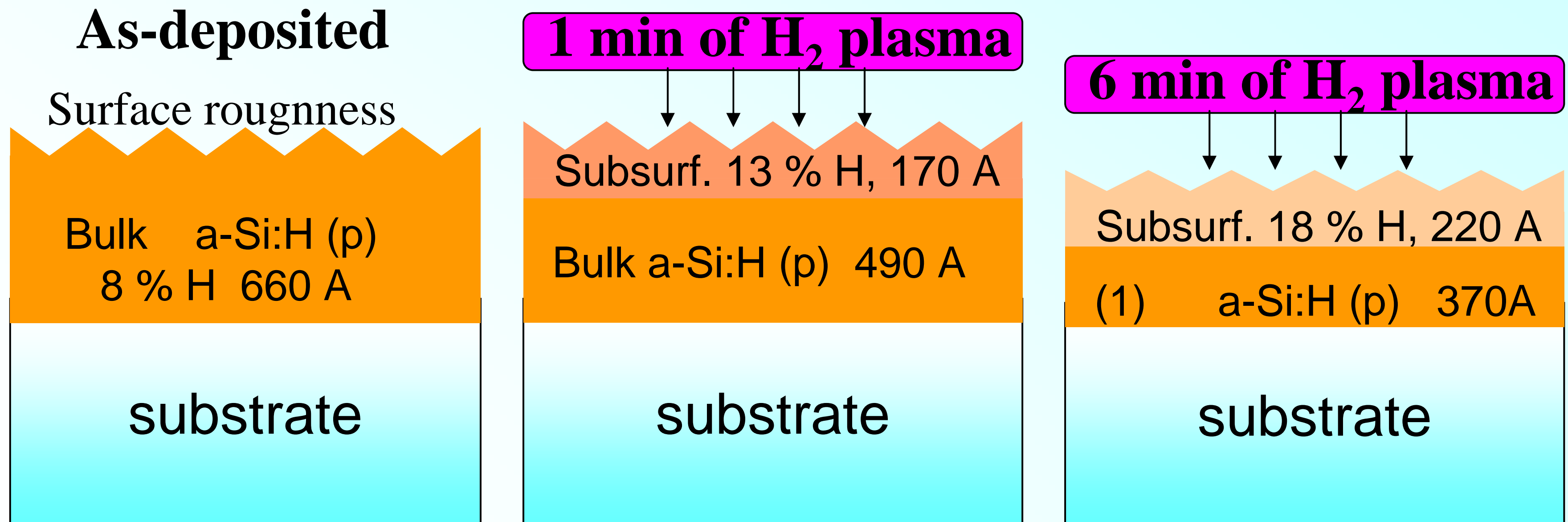
Optical Model

1. Tauc's Lorentz model to analyze the a-Si:H substrate
2. Tetrahedron model to take into account the effect of hydrogen
3. BEMA: the dielectric function of the material exposed to hydrogen is described as a mixture of the initial a-Si:H, plus voids, plus Si-Si_3H



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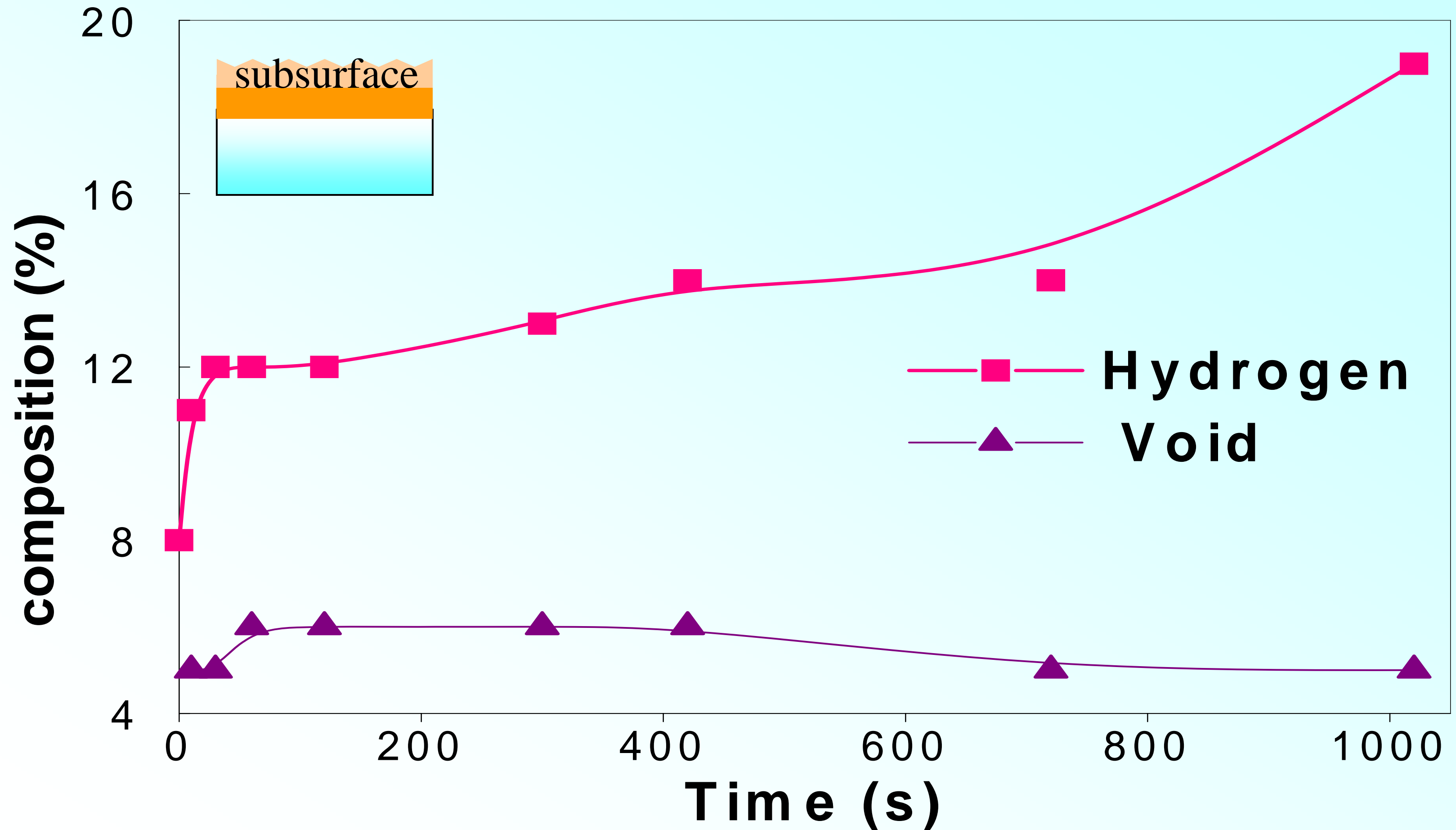
Analysis of the SE data on a-Si:H

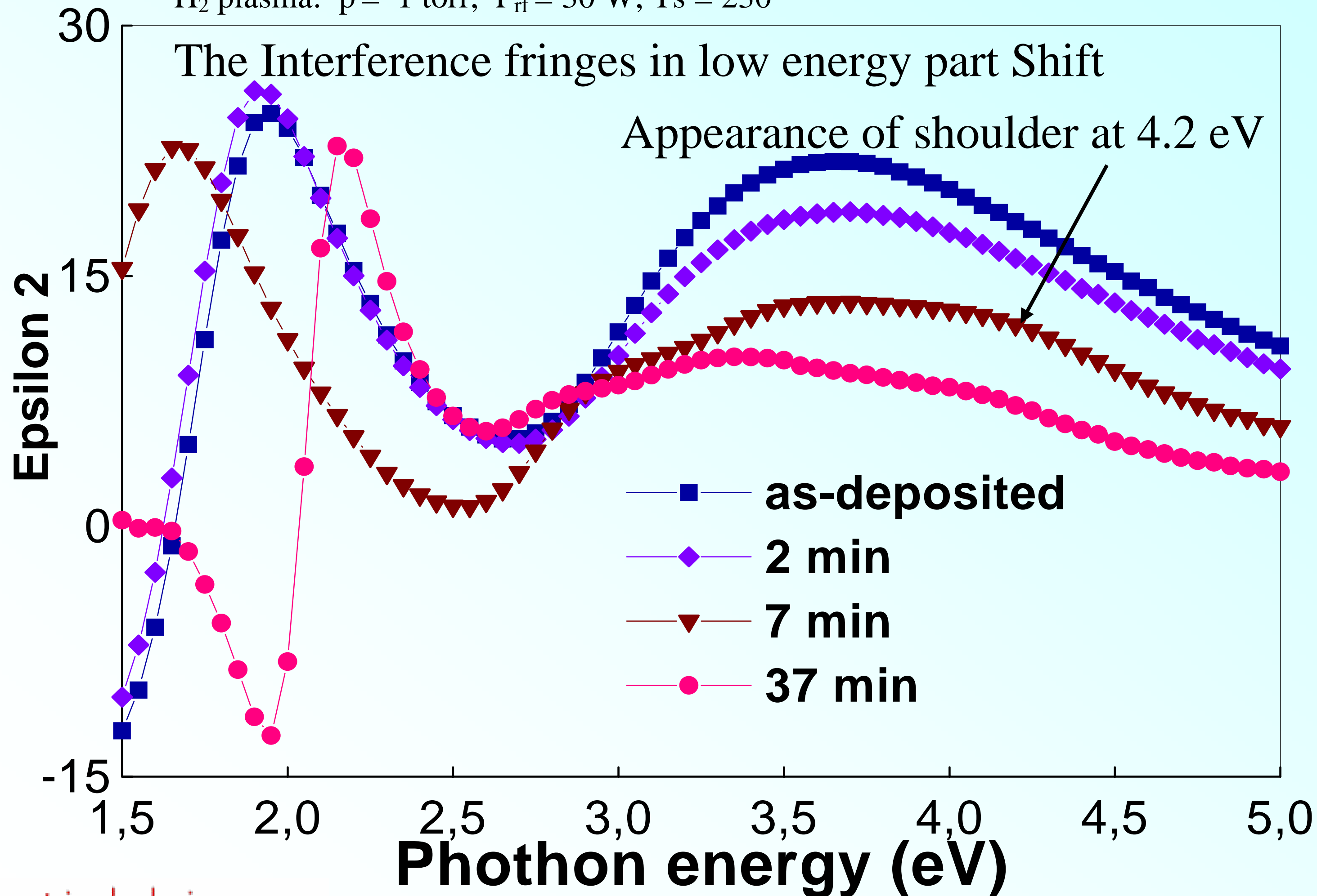


II. Chemical transport in a-Si:H

S.Veprek, al, J. Phys; C 14 (1968)

a-Si:H deposition : p = 60 mtorr, P_{rf} = 5 W, T = 230°C.

H_2 plasma: p = 1 torr, P_{rf} = 30 W, Ts = 230°



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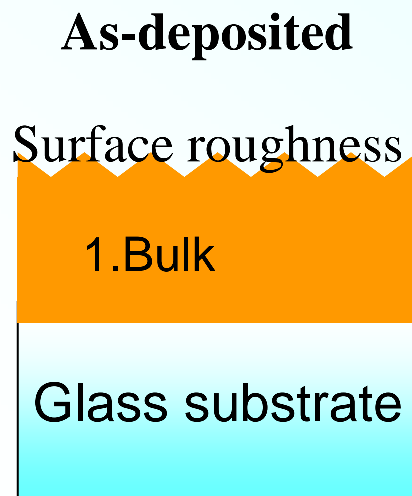
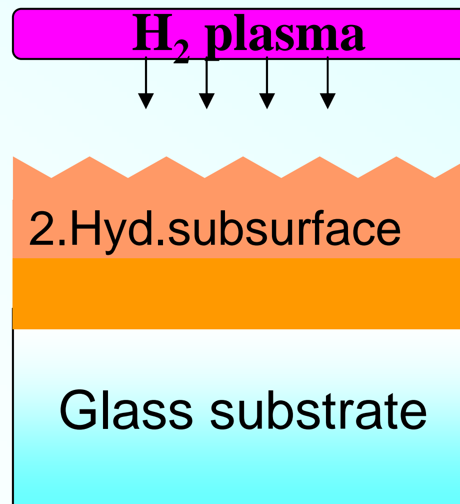
Optical Model

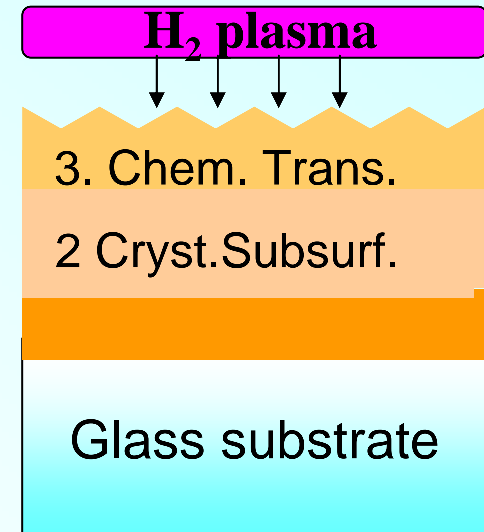
Bruggeman Effective Medium Approximation (B.E.M.A)

0. Roughness: Amorphous (Aspnes) + Void
1. Bulk: Amorphous (Aspnes) + Void
2. Subsurface layer : Amorphous + Void +µc cristallin
3. Chemical Transport Layer :Amorphous + Void + µ-cristallin

As-deposited







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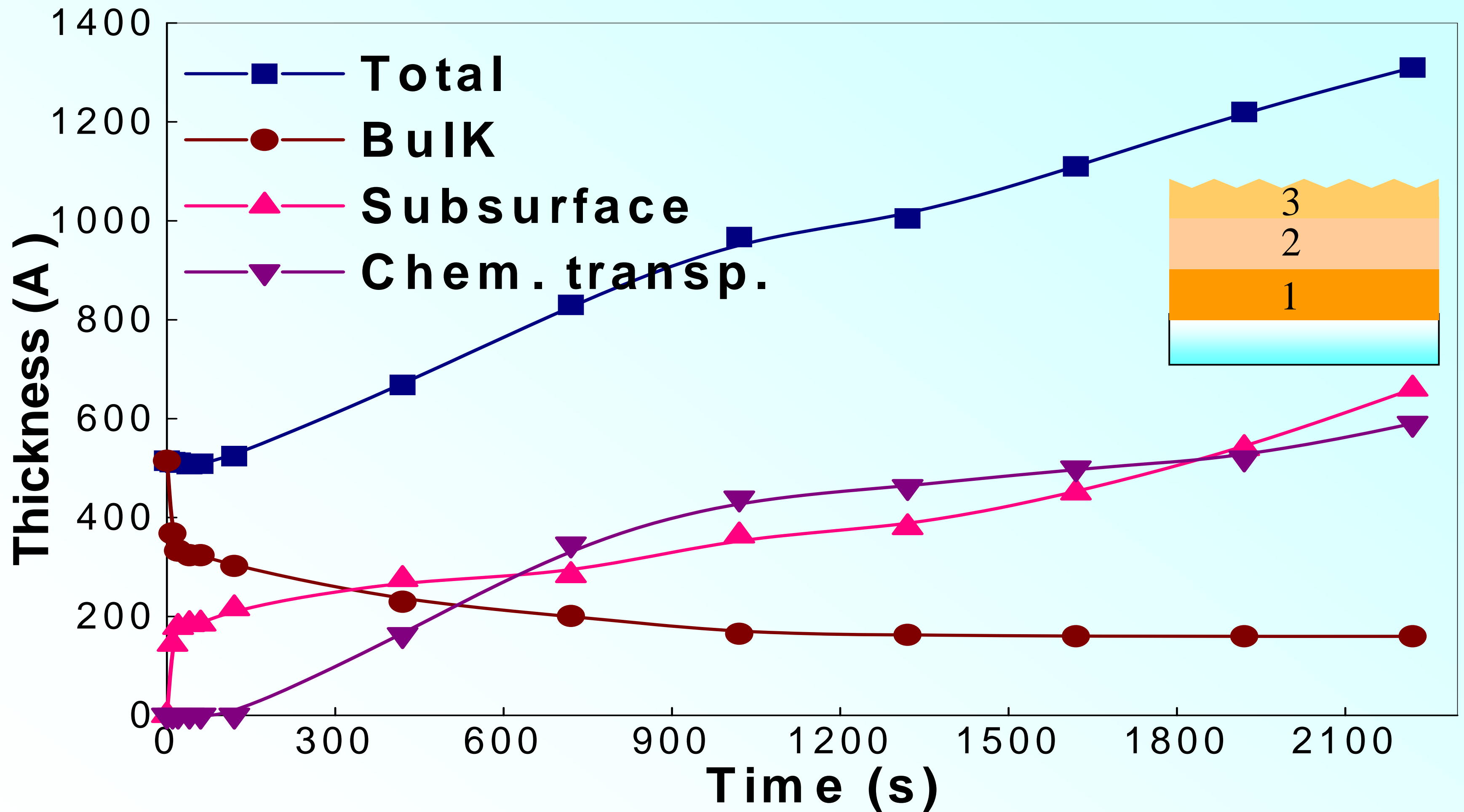

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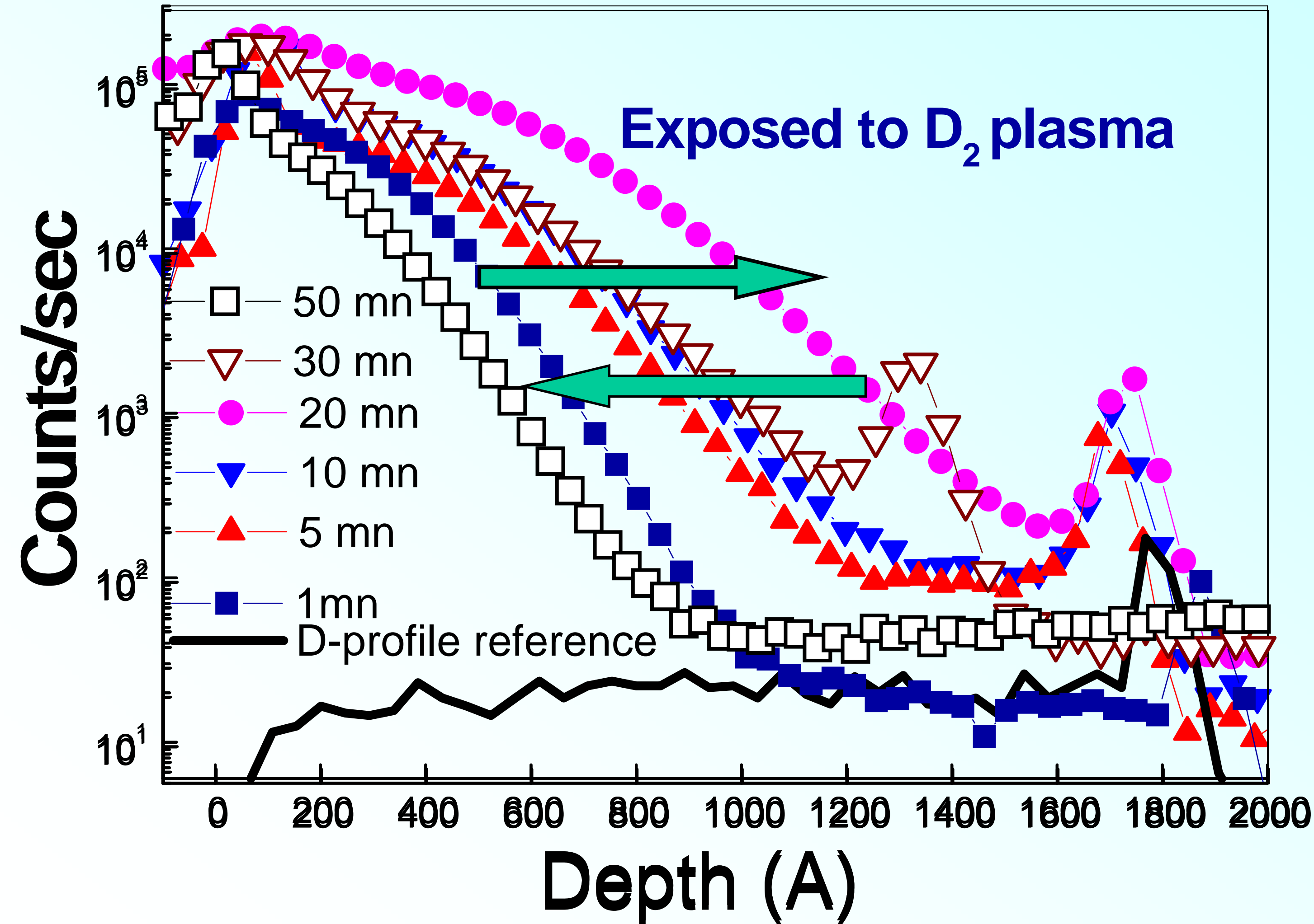
III. Results: SIMS measurements Deuterium profiles



D diffuses to the back of the sample

Afterwards to the crystallized region !

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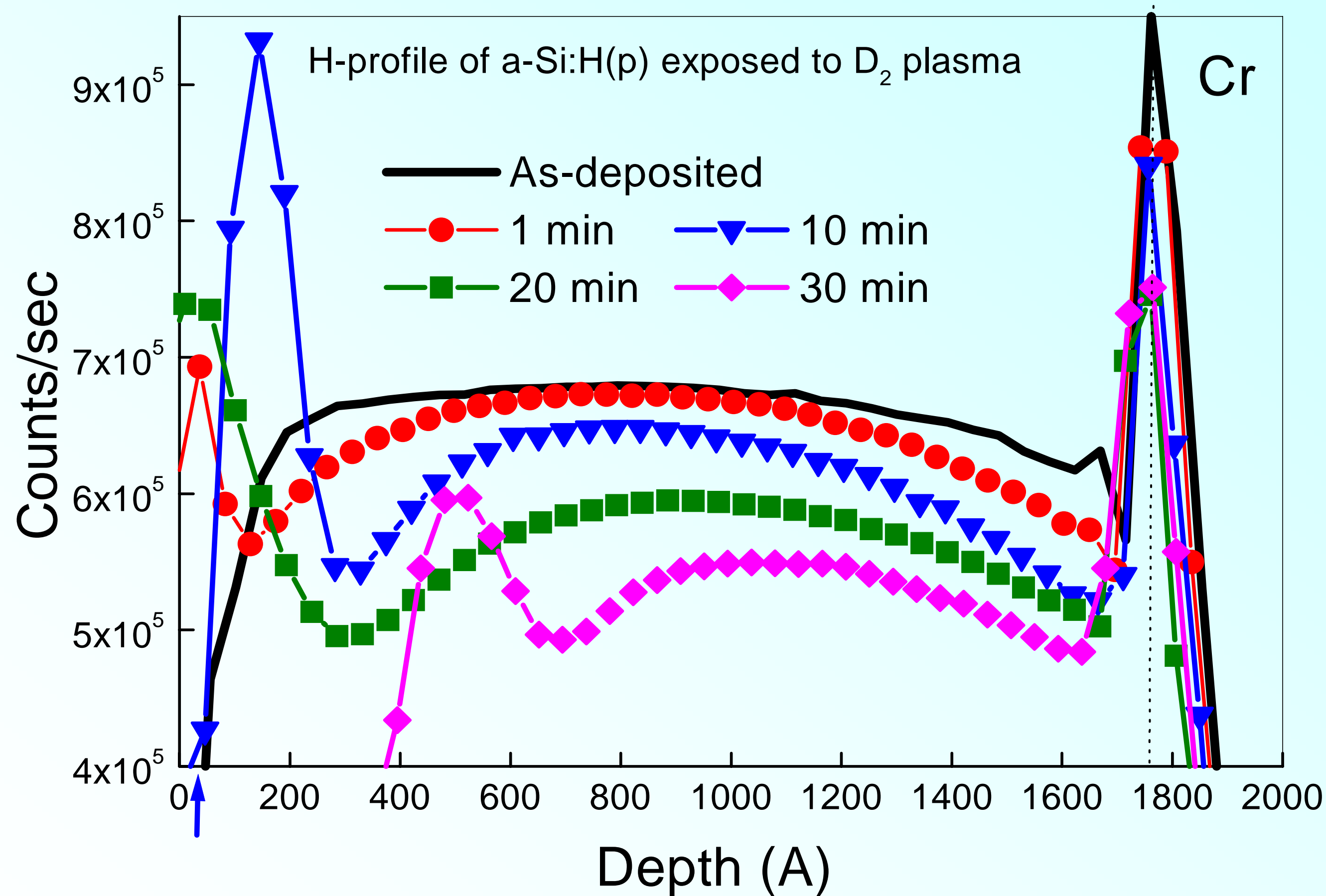
III. Results: SIMS measurements Hydrogen profiles



Hydrogen moves towards the crystallization region

Once the crystallization starts, H-accumulation decreases

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IV. Summary and Conclusion

- ***Hydrogen plasma exposure of a-Si:H films starts by the formation of a hydrogen rich subsurface layer***

- ***This process leads to:***

  Etching when hydrogen is alone in plasma (clean walls)

  Deposition of μc-Si:H film by chemical transport when the walls are **a-Si:H coated walls**

IV. Summary and Conclusion

Once a microcrystalline silicon film is formed, both deuterium and Hydrogen move towards the surface and are removed from the sample

WHY ?

Heterojonction effect ?

Your suggestions are welcome !