Simulation of Hydrogen Ion Diffusion for LTPS Thin-film Transistors
Contents

• Hydrogen Ion diffusion for LTPS TFT
• Models
• Demo example
• Summary
Importance

Fig. 1. Comparison of subthreshold characteristics for as-fabricated and fully hydrogenated (16 h) poly-TFT’s processed with a maximum temperature of 600°C.

Effects of Trap-State Density Reduction by Plasma Hydrogenation in Low-Temperature Polysilicon TFT

I-WEI WU, ASSOCIATE MEMBER, IEEE, ALAN G. LEWIS, MEMBER, IEEE, TIAO-YUAN HUANG, MEMBER, IEEE, AND ANNE CHIANG, SENIOR MEMBER, IEEE

IEEE ELECTRON DEVICE LETTERS, VOL. 10, NO. 3, MARCH 1989
Hydrogen Ion Diffusion Paths?

FIG. 3. Possible pathways for hydrogen migration from a gaseous source to the semiconducting poly-Si layer of a thin-film transistor structure. In path A1 the H must pass through the overlayers, the gate electrode, and the gate oxide to reach the channel. In paths A2 and A3 the hydrogen moves through the overlayers and source-drain contacts into the gate oxide. For path A2 the H diffuses rapidly laterally within the oxide and then into the channel, while for path A3 the H enters the poly-Si and then diffuses rapidly in the lateral direction within the poly-Si. A final possibility, A4 is H diffusion into the quartz substrate, lateral diffusion to the center of the device, then through the active poly-Si into the channel region.

Hydrogen diffusion in polycrystalline silicon thin films

W. B. Jackson, N. M. Johnson, C. C. Tsai, I.-W. Wu, A. Chiang, and D. Smith
Xerox Palo Alto Research Center, 3333 Coyote Hill Road, Palo Alto, California 94304
(Received 4 June 1992; accepted for publication 28 July 1992)

Grain boundaries in undoped polycrystalline silicon (poly-Si) thin films are shown to act as efficient hydrogen traps rather than as paths of enhanced diffusion. A comparison of hydrogen diffusion in poly-Si and undoped single-crystal silicon (c-Si) demonstrates that the diffusion in poly-Si is significantly suppressed compared to c-Si. These results have significant implications for hydrogenation of poly-Si thin-film transistors.
Contents

• Hydrogen Ion diffusion for LTPS TFT
• Models
• Demo example
• Summary
**Diffusion Theory**

Diffusion coefficient maybe dependent on material orientation, stress, and proximity to boundary

\[ \nabla \cdot D_s \nabla S_h - \frac{S_h}{\tau_h} - \frac{dS_h}{dt} = 0 \]

H-ion flux density from material 1 to material 2 (segregation model)

\[ J_s(1 - to - 2) = v_h(S_{h1} - S_{h2}/M_{12}) \]

\[ M_{12} = SS_1/SS_2 \]

Diffusion with H-ion (Sh) loss due to recombination with local defects or traps

Sensitive to solid solubility (SS). H-ion tends to segregate at low SS material.
Contents

• Hydrogen Ion diffusion for LTPS TFT
• Models
• Demo example
• Summary
Hysteresis found in both n-channel and p-channel TFT. Defects/traps are the cause!
Ref structure with defects at LTPS
Hydrogen ions were initially assumed to be located in SiN and later subjected to 20 min diffusion at 400°C.
Assuming H-ions removes/disable defects/traps, even a simple demo structure with simplified diffusion model is able to predict the correct trends.
Summary

• Sophisticated H-ion diffusion model implemented with device simulator as preprocessor
• Directly interact with defects/traps in device modeling
• Without little calibration effort, correct trends produce in device demo.
Thanks for your attention!