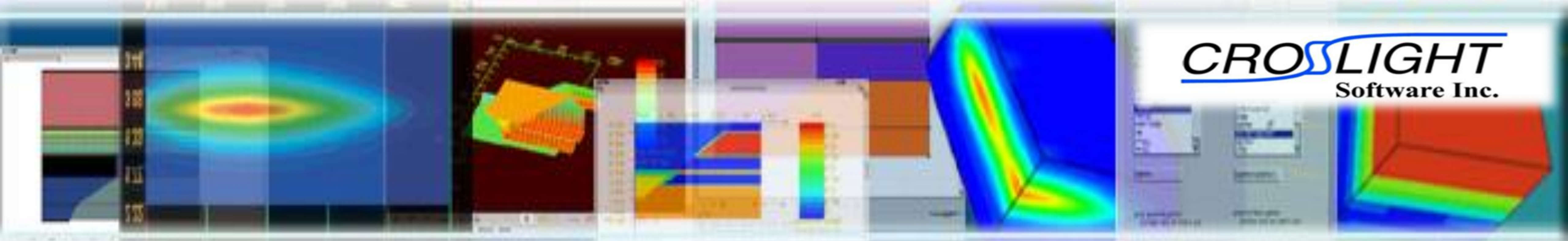

Simulation of Hydrogen Ion Diffusion for LTPS Thin-film Transistors

CROSSLIGHT Software Inc.

Contents

- Hydrogen Ion diffusion for LTPS TFT
- Models
- Demo example
- Summary

Importance

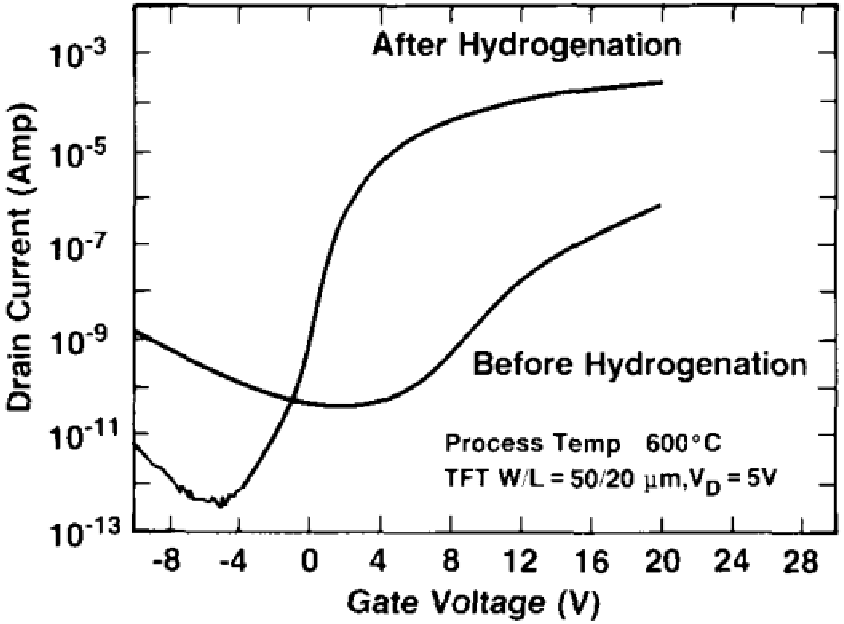

Fig. 1. Comparison of subthreshold characteristics for as-fabricated and fully hydrogenated (16 h) poly-TFT's processed with a maximum temperature of 600°C.

IEEE ELECTRON DEVICE LETTERS, VOL. 10, NO. 3, MARCH 1989 123

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

Hydrogen Ion Diffusion Paths?

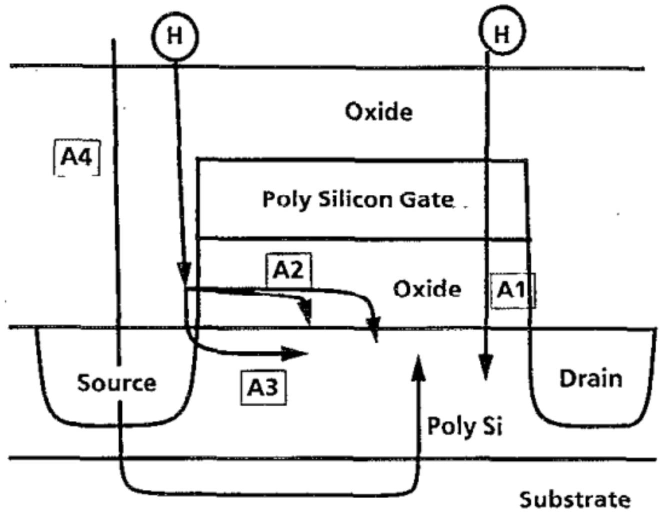

FIG. 3. Possible pathways for hydrogen migration from a gaseous source to the semiconducting poly-Si layer of a thin-film transistor structure. In path A1 the H must pass through the overlayers, the gate electrode, and the gate oxide to reach the channel. In paths A2 and A3 the hydrogen moves through 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.

1670 Appl. Phys. Lett. 61 (14), 5 October 1992 0003-6951/92/391670-03$03.00 © 1992 American Institute of Physics 1670

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Diffusion Theory

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

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

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

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

$$M_{12} = SS_1/SS_2$$

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

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

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demo example

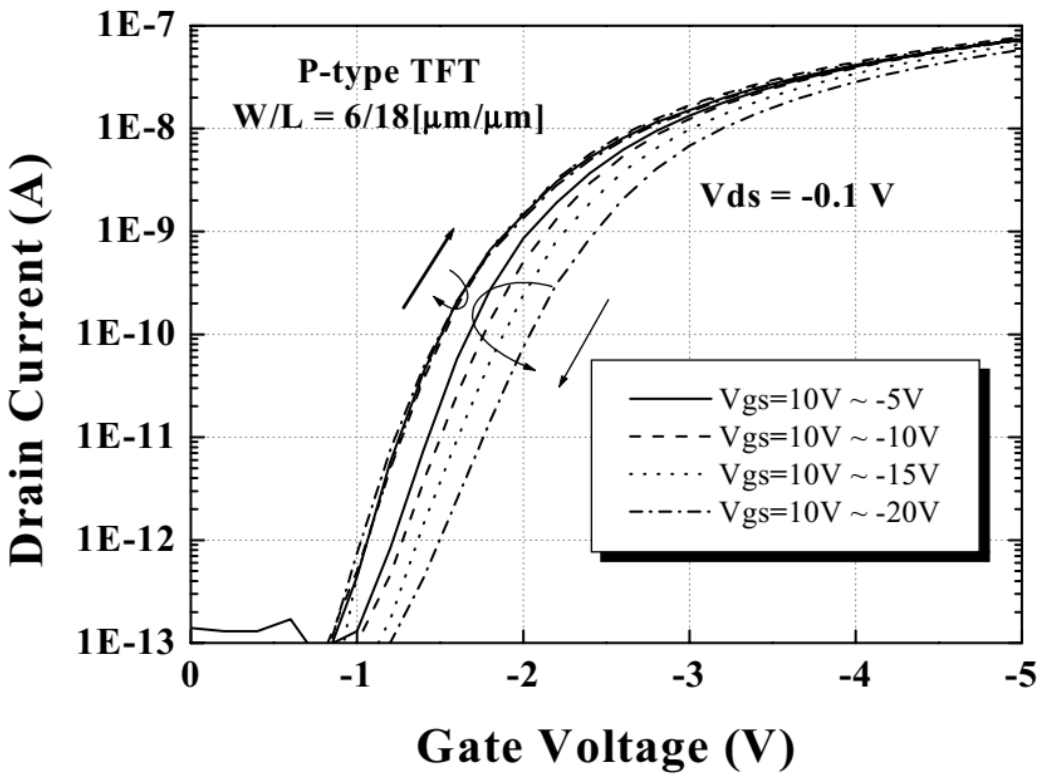
Hysteresis found in both n-channel and p-channel TFT

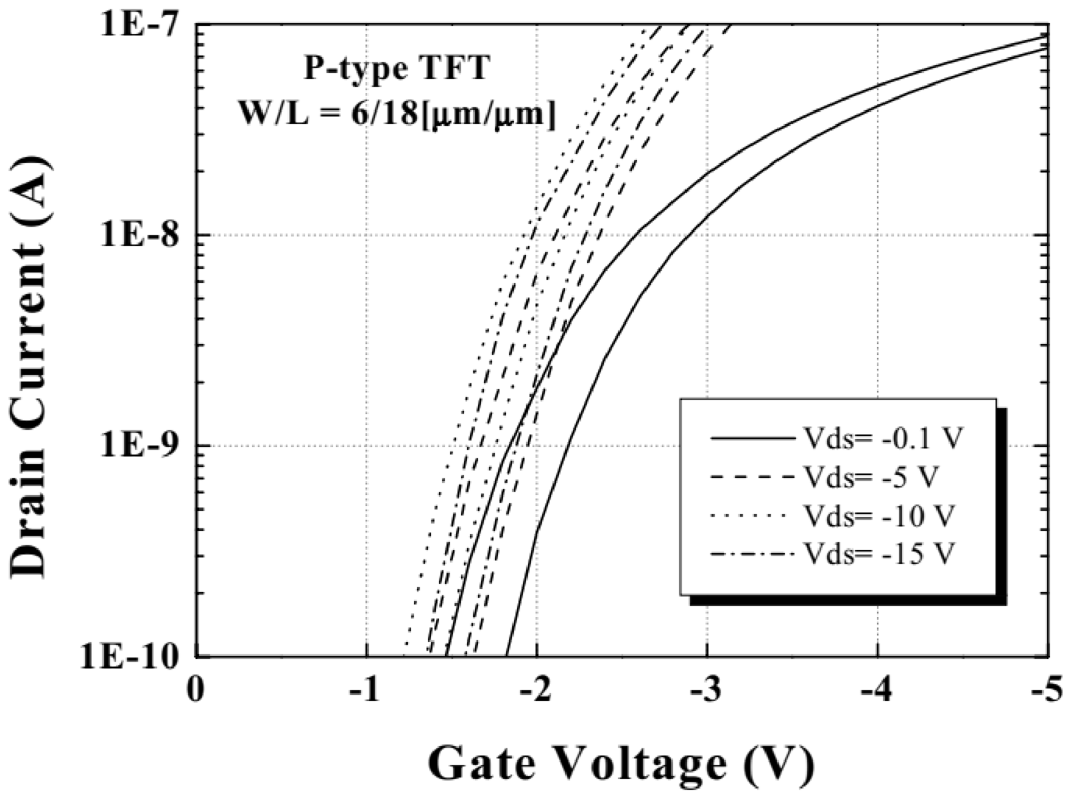
Defects/traps are the cause!

Journal of Information Display, vol. 6, no. 4, 2005

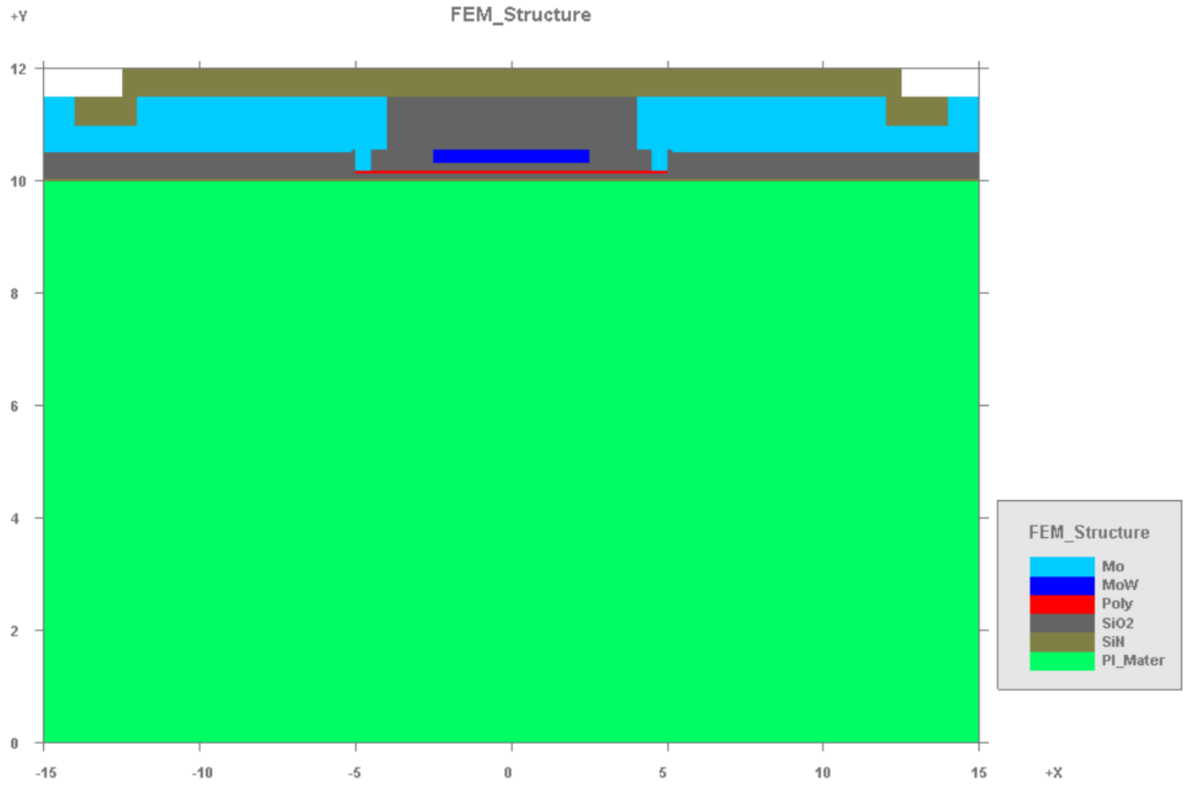
Hysteresis Characteristics in Low Temperature Poly-Si Thin Film Transistors

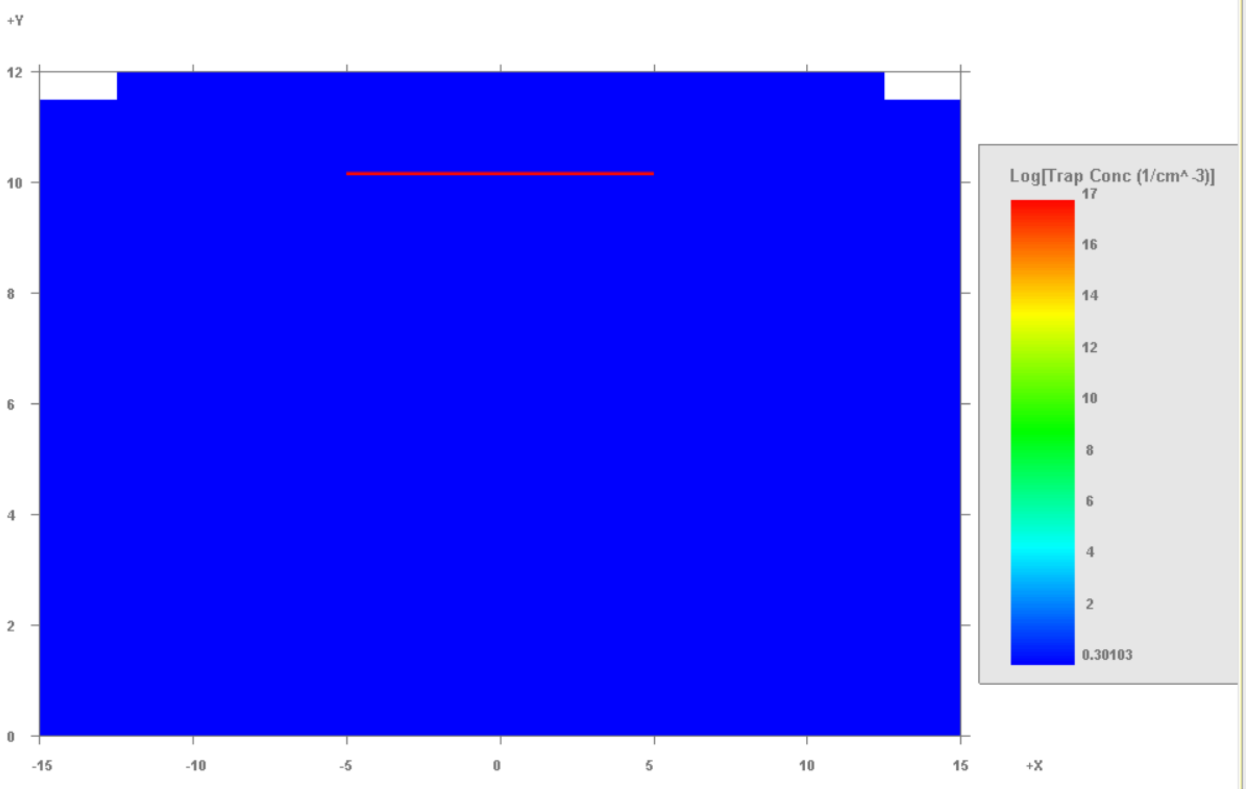
Hoon-Ju Chung[*a], Dae-Hwan Kim[b], and Byeong-Koo Kim[*b]



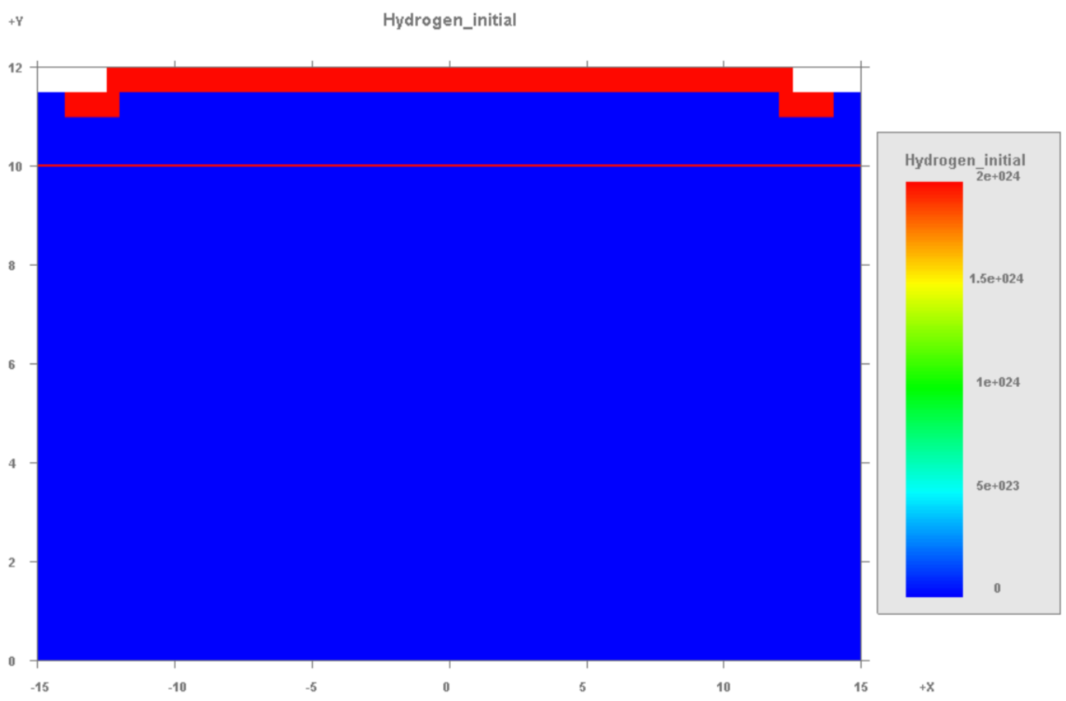


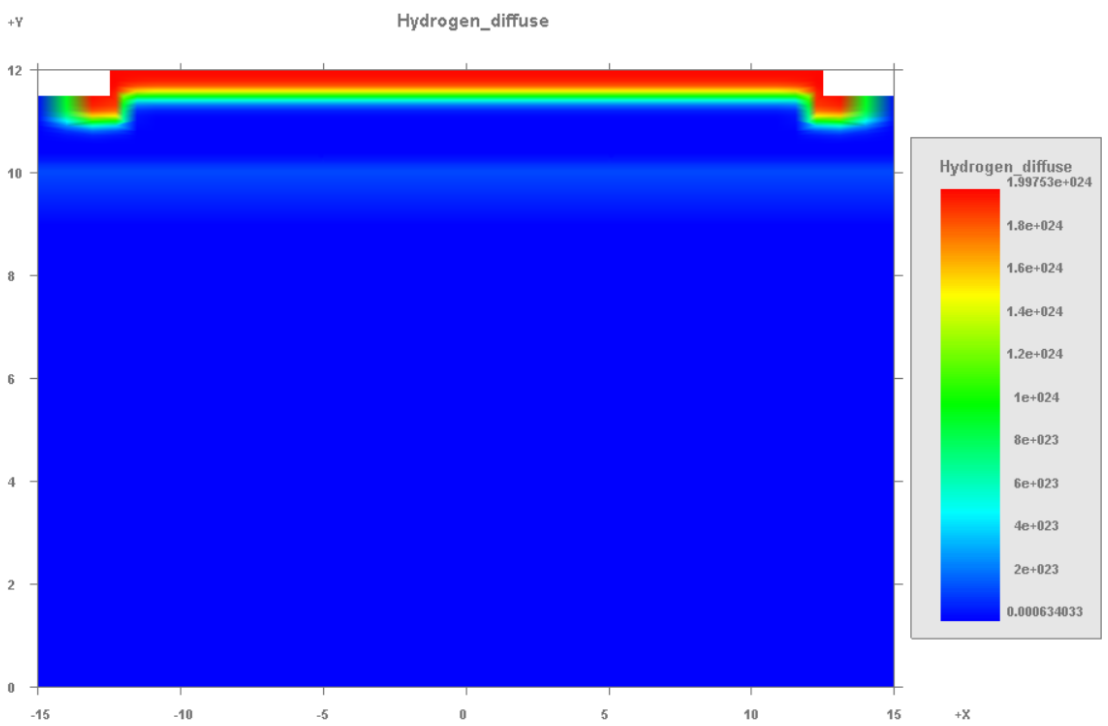
Ref structure with defects at LTPS

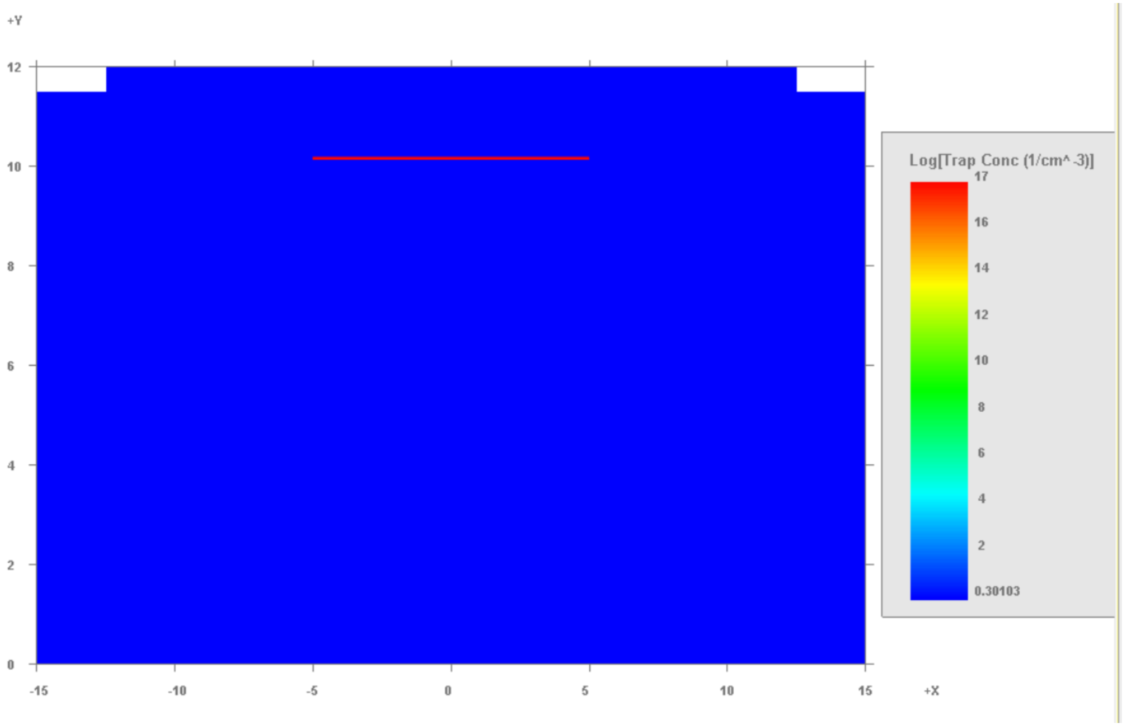


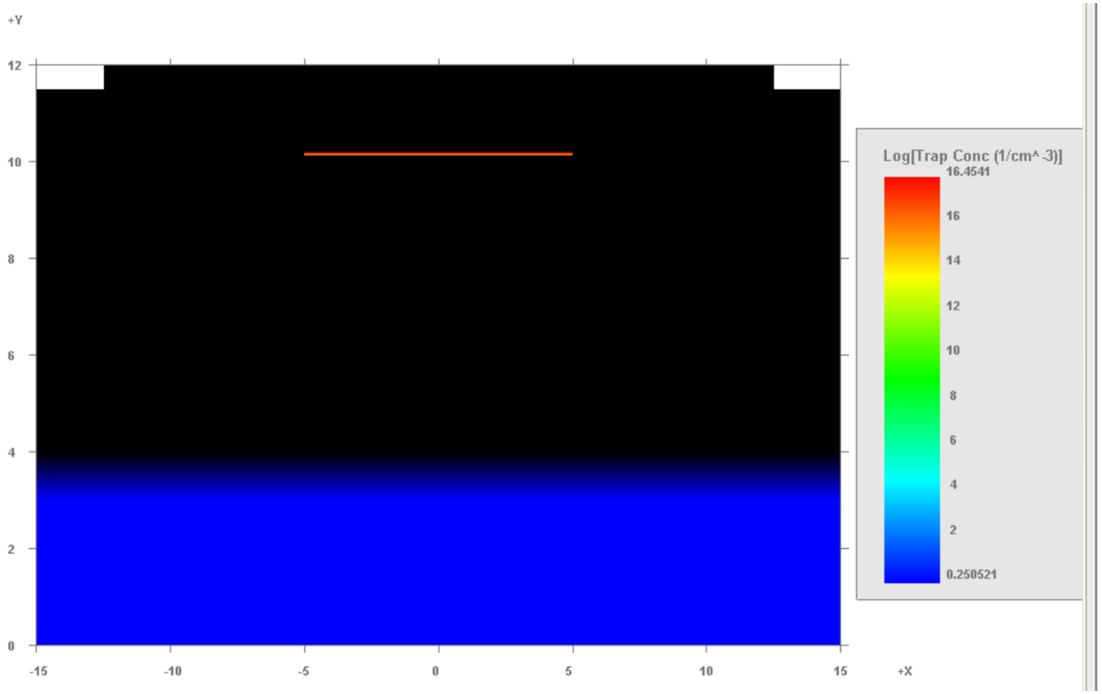


Hydrogen ions were initially assumed to be located in SiN and later subjected to 20 min diffusion at 400C






+Y
12
10
8
6
4
2
0
-15
-10
-5
0
5
10
15
+X
Log[Trap Conc (1/cm^-3)]
17
16
14
12
10
8
6
4
2
0.30103


+Y
12
10
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6
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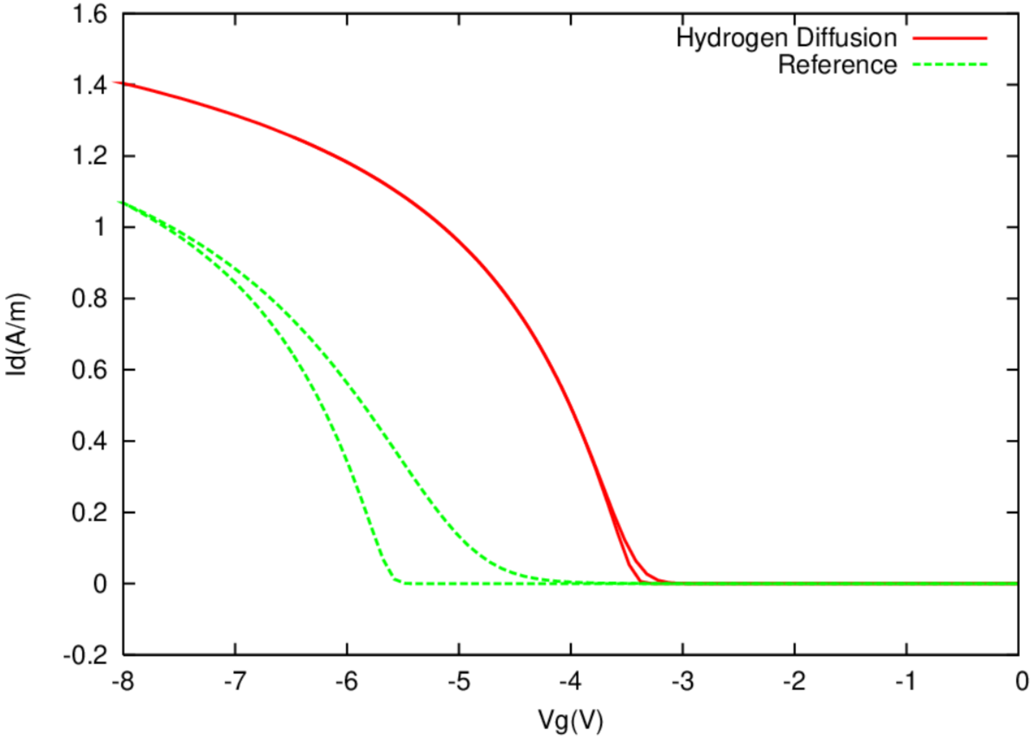
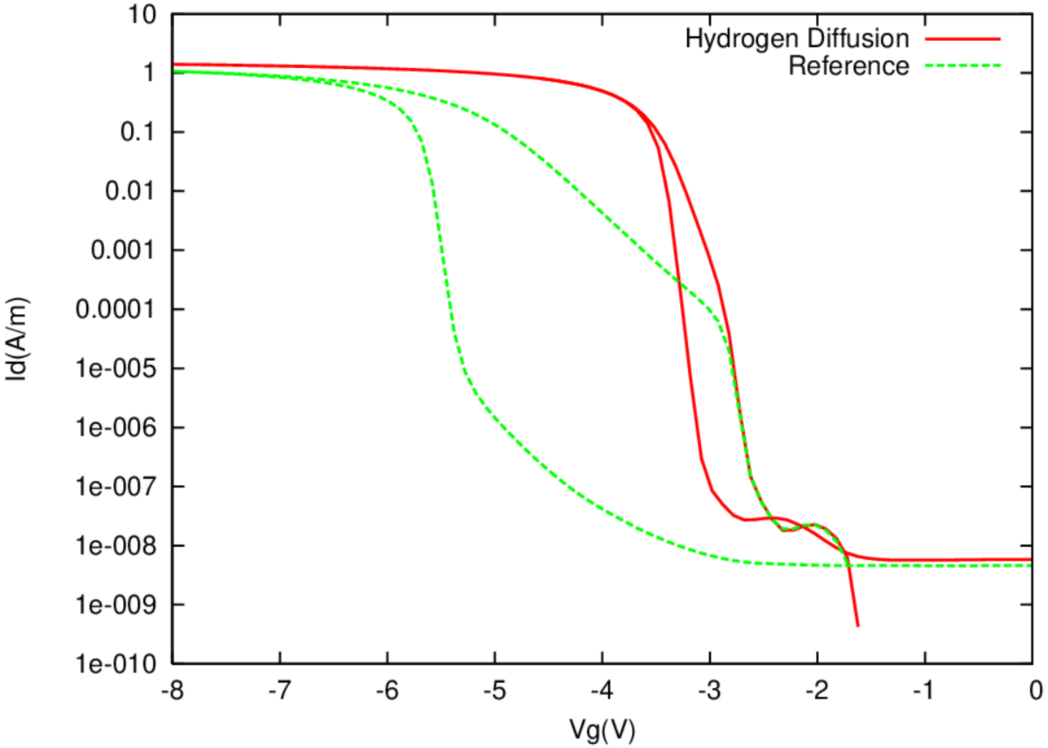
2
0
-15
-10
-5
0
5
10
15
+X
Log[Trap Conc (1/cm^-3)]
16.4541
16
14
12
10
8
6
4
2
0.250521

Assuming H-ions removes/disable defects/traps, even a simple demo structure with simplified diffusion model is able to predict the correct trends.

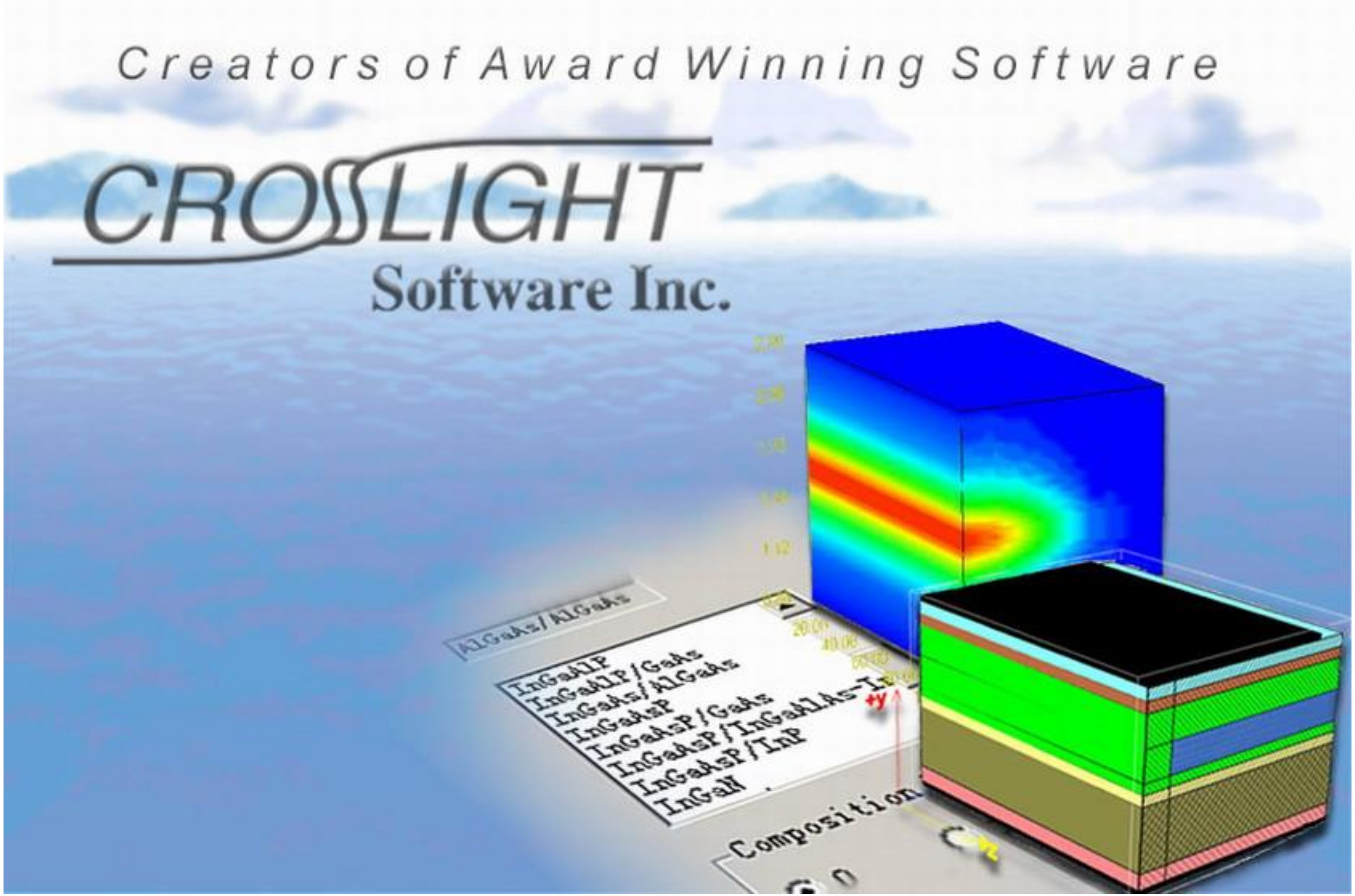




Summary

- 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!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InGaAsP/InP
InGaN
Composition