The ICMCTF , the Town & Country Hotel and Convention Center, San Diego, California, USA, May 21-26 2023.

Functional Thin Films and Surfaces, Room Pacific C,
Session C1-1-WeM, Optical Marials and Thin Films I, Wednesday, May 24, 2023, C1-1-WeM5 (9:20 - 9:40)

High Hall Mobility W-Doped In_2O_3 Conductive Films with Thicknesses of Less Than 10 nm Deposited on Glass Substrates

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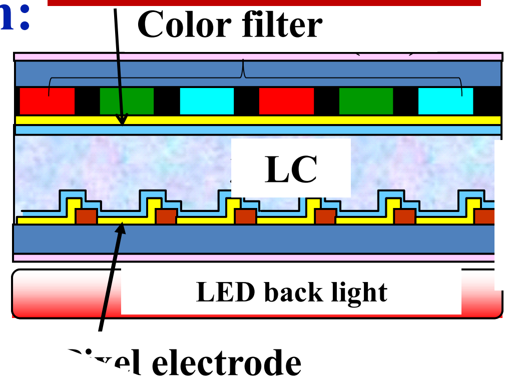
Sheet resistance ranges of transparent conductive films for various applications

$R_s\ (\Omega\ sq^{-1}) = \rho/t$ (thickness) $\propto 1/t \cdot 1/(n_e \mu_H)$

***Note:* *t* of more than 100 nm**

Scattering mechanism:
T. Terasako, *et al.*,
Thin Solid Films,
528 (2013) 19.

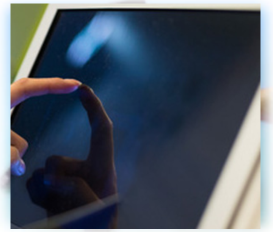
Common electrode:
R_S < 30 Ω/Sq. @ 150nm



LCD TV

Thin Solid Films
520 (2012) 4131.

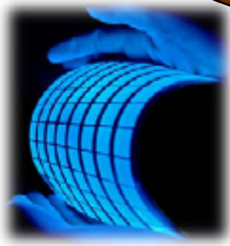
500 400 300 200 100 10 1 (Ω sq^{-1})



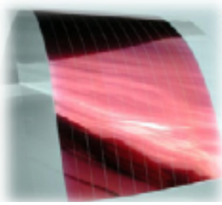
Touch screen

Smart window

Flexible LCD



Flexible OLED



Solar cell

Linxiang HeSie, ChinTjong,
Mater. Sci. Engineering, 109 (2016) 1.

For wide applications, to develop a low-temperature process with Solid Phase Crystallization

Firstly, *n*-type doped amorphous (*a*-) In_2O_3 films deposited on glass substrates at room temperature.
Then, the *a*-films are annealed at temperatures ranging from 150 to 300 °C for 30 min in air or under vacuum condition, to achieve high Hall mobility transparent conductive polycrystalline In_2O_3 films.

Ce-doped In_2O_3: thickness was 100 nm.
E. Kobayashi, Y. Watabe, T. Yamamoto, APEX, 8 (2015) 015505.
E. Kobayashi, Y. Watabe, T. Yamamoto, Y. Yamada, Sol. Energy Mater., Sol. Cells, 149 (2016) 75. cells: *commercially* solar cells

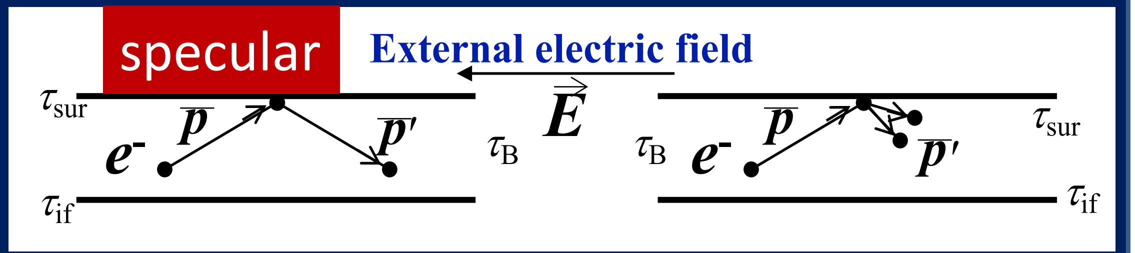
W-doped In_2O_3: thicknesses range *from 5 to 50 nm*.

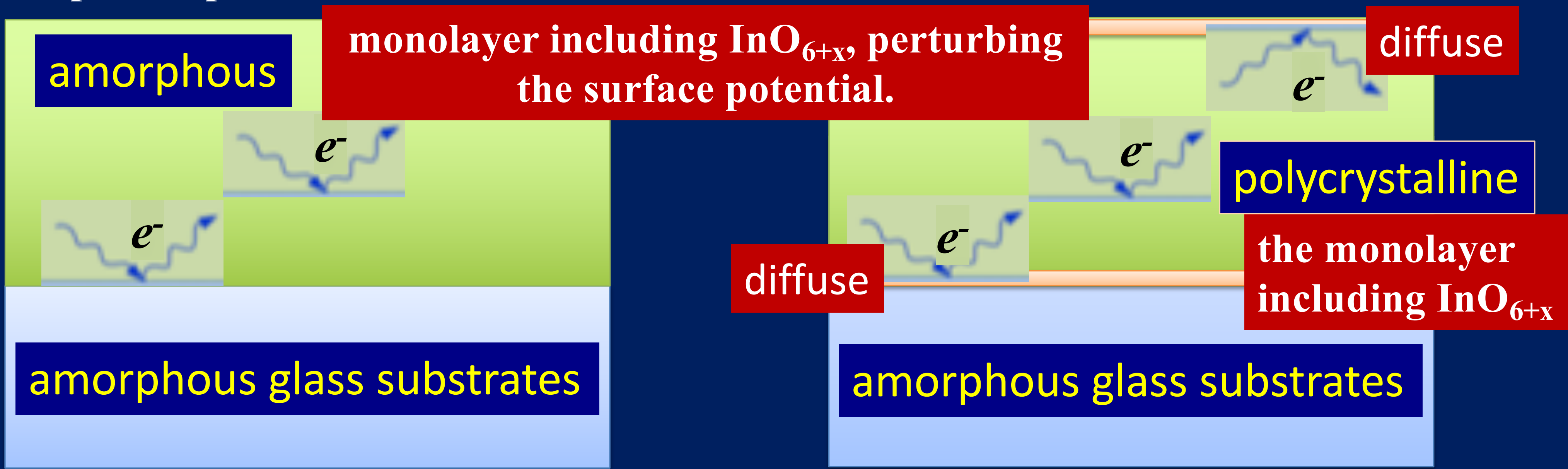
Y. Furubayashi, M. Maehara, T. Yamamoto, J. Physics D, 37 (2020) 375103.
Y. Furubayashi, S. Kobayashi, M. Maehara, K. Ishikawa, K. Inaba, T. Sakemi, H. Kitami, T. Yamamoto, APEX, 13 (2020) 065502.

What determines carrier transport ?

before/after solid phase crystallization

Diffuse scattering causes randomization of the electron momentum while **specular scattering** conserves the electron momentum component parallel to the surface.





Conclusions

We successfully achieved *p*-IWO films showing a high μ_H with the under-vacuum solid-phase crystallization of *a*-IWO films on glass substrates.

issue: to mitigate the carrier transport bottleneck by facilitating specular electron interface scattering

For ultra-thin IWO films,
a diffuse scattering mechanism at the surfaces and film/substrate interfaces would cause a reduction in μ_H;
the presence of excess O atoms in the vicinity of the surfaces and near the film/substrate interfaces may be a factor limiting μ_H.