Australian National University

Luminescence from poly-Si films and its applications in Si PV

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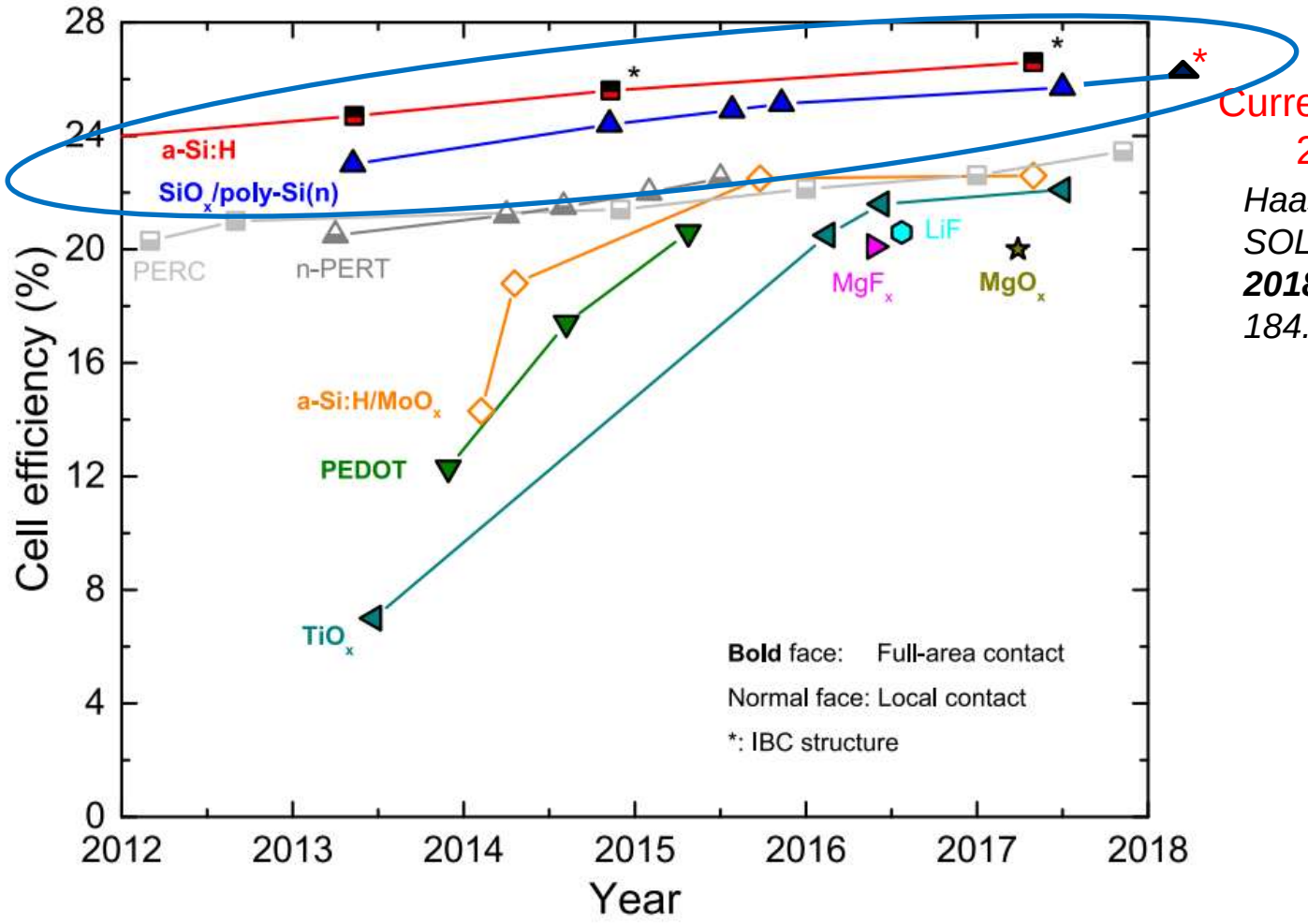
Motivation



Current record: 26.1%

*Haase et al., SOLMAT **2018**, 186, 184.*

Source: Melskens et al., IEEE JPV 2018, 8, 373.

poly-Si films also absorb light → could yield PL signal

Outline

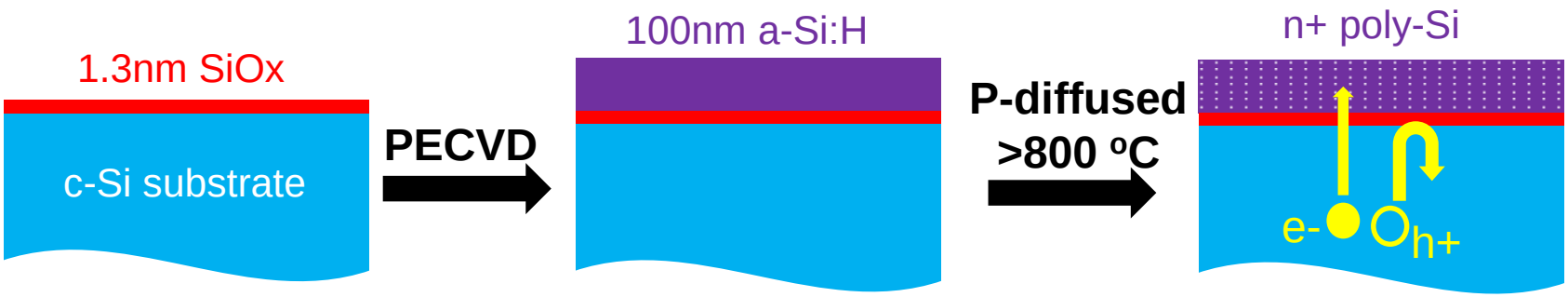
Doped poly-Si films:

+ Formation and microscopic structures
+ Luminescence

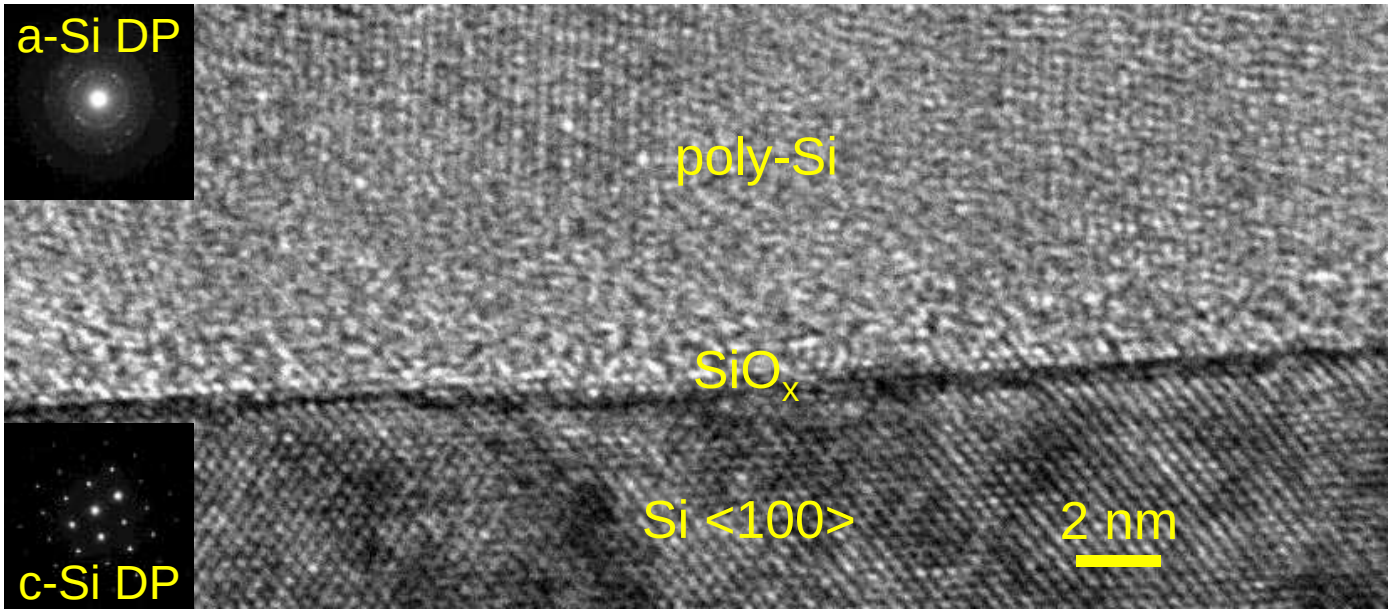
Applications of poly-Si luminescence

+ Carrier transport
+ Hydrogenation effects

Formation and microscopic structures

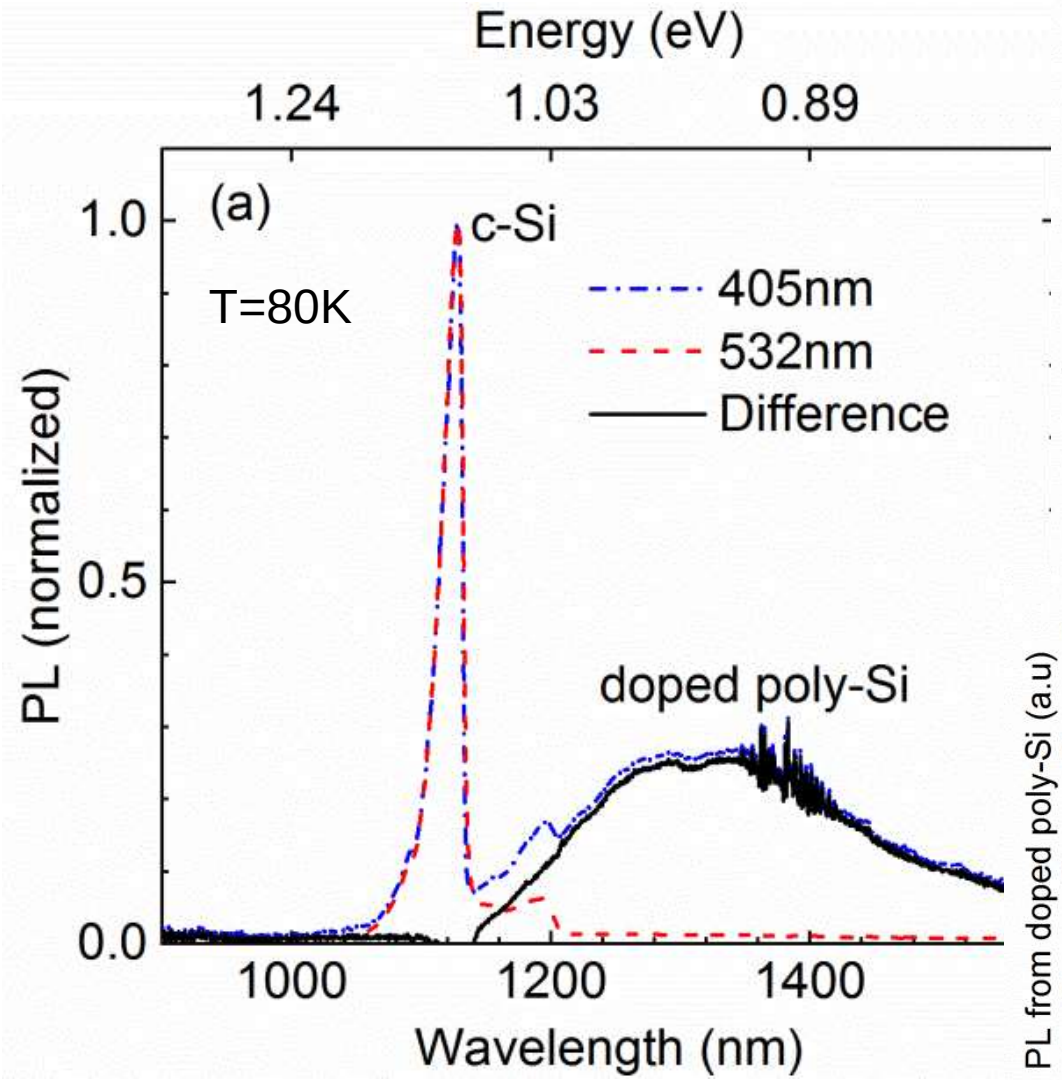


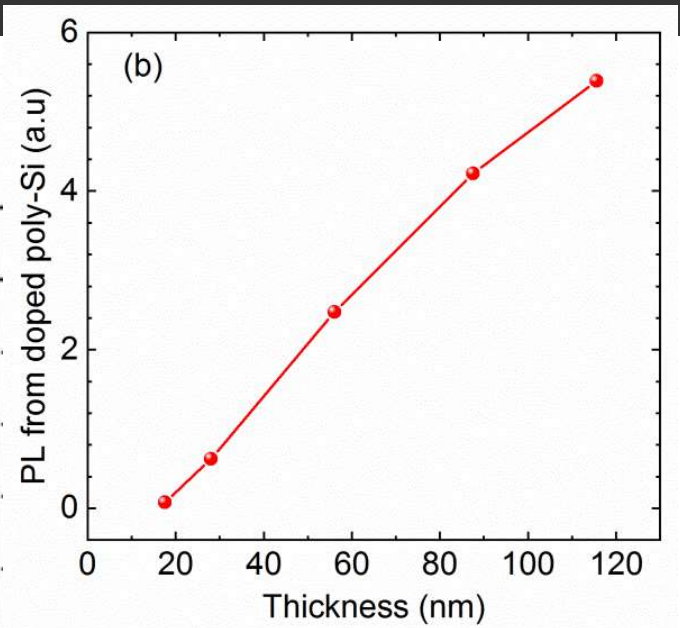
TEM image

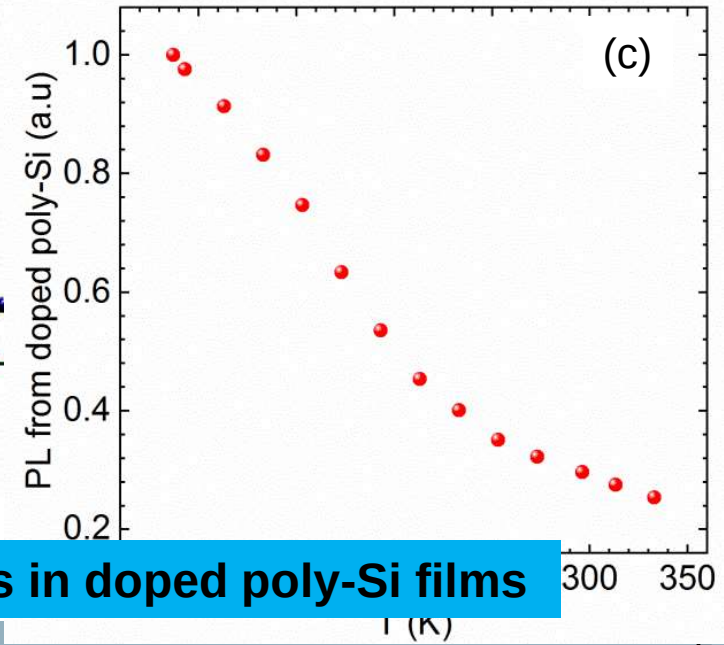


Doped poly-Si films contain both amorphous and crystalline phases

PL from doped poly-Si films

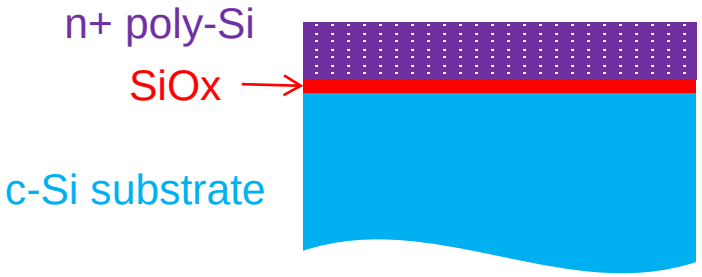


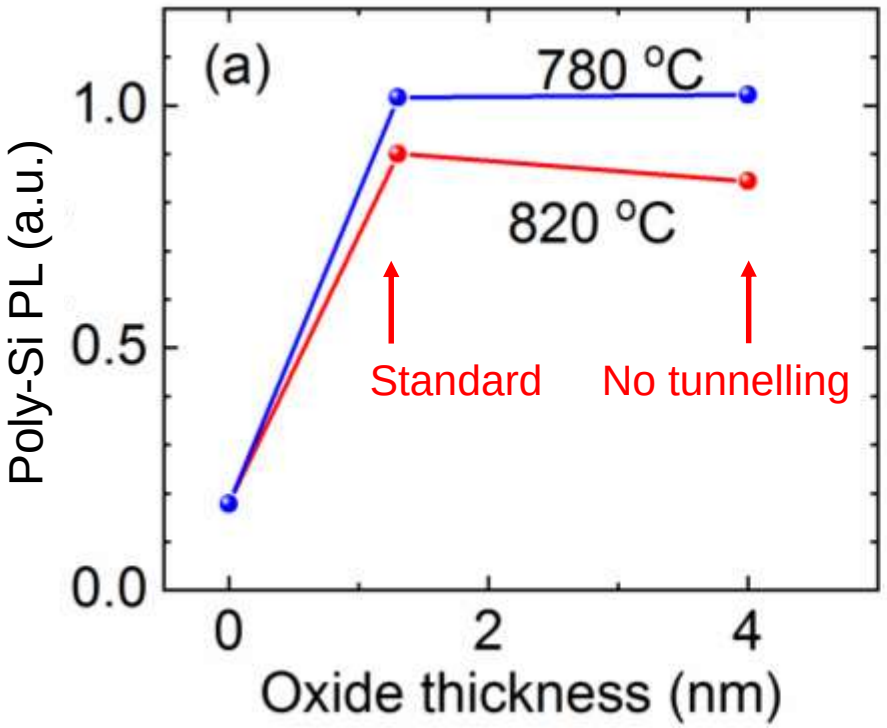


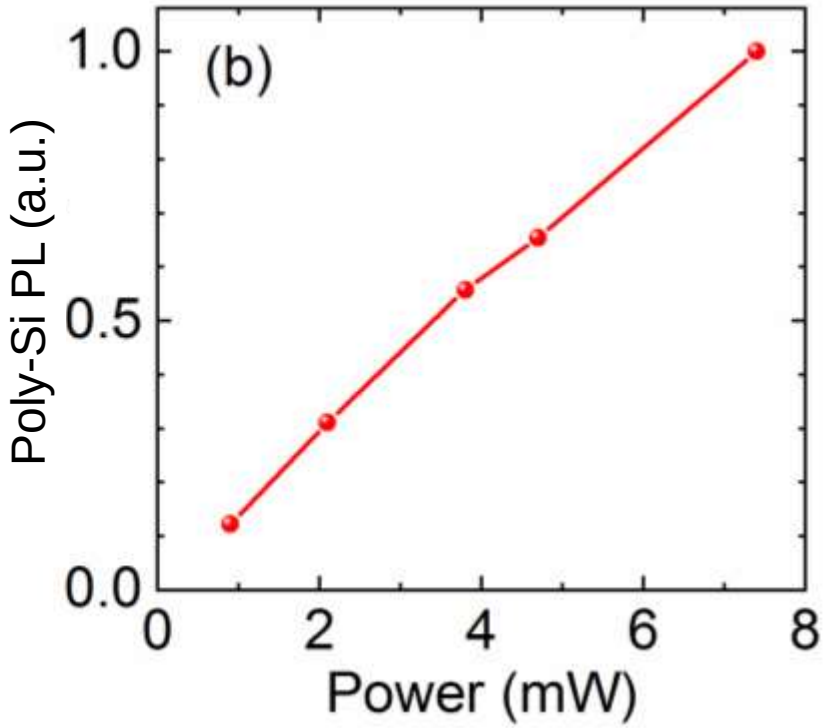


PL (1250-1500nm) is from radiative defects in doped poly-Si films

Investigating carrier transport (1/2)



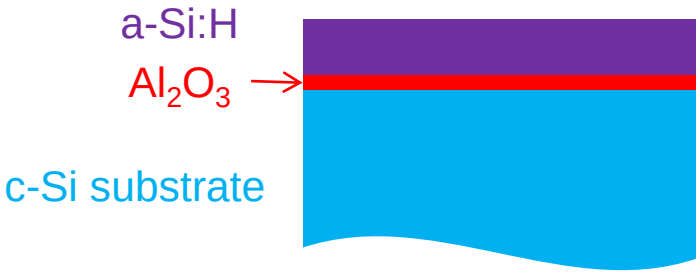


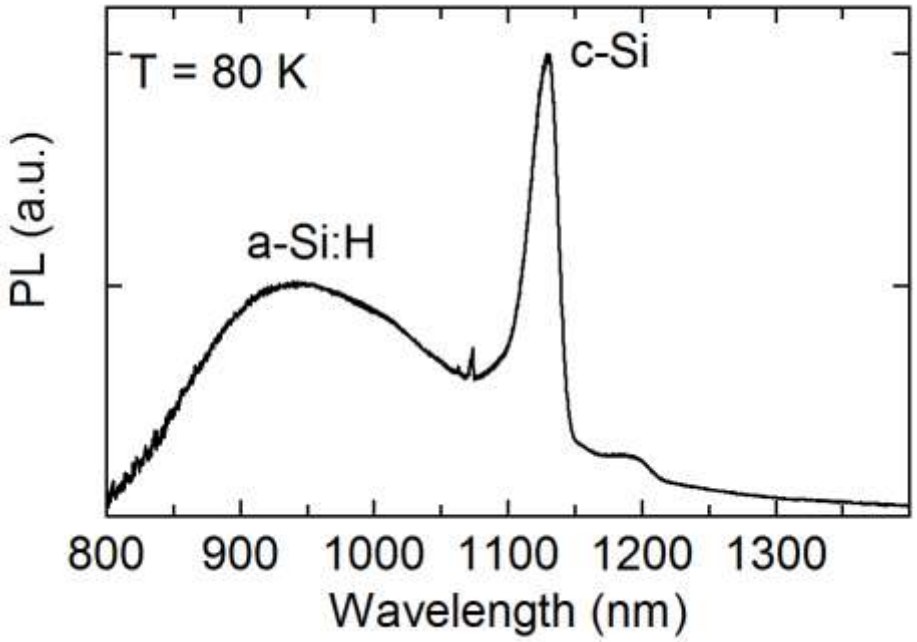


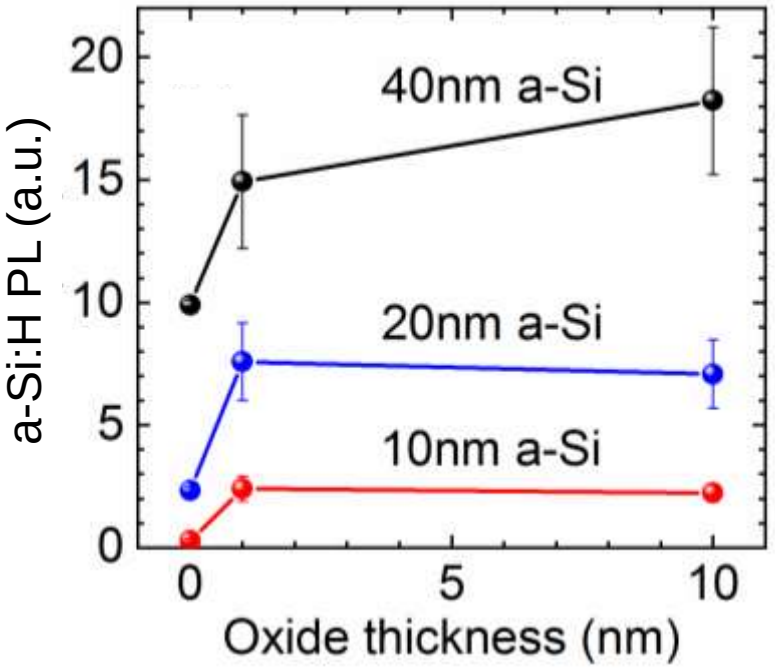
No carrier coupling from doped poly-Si films

Investigating carrier transport (2/2)

Extended to a-Si:H films



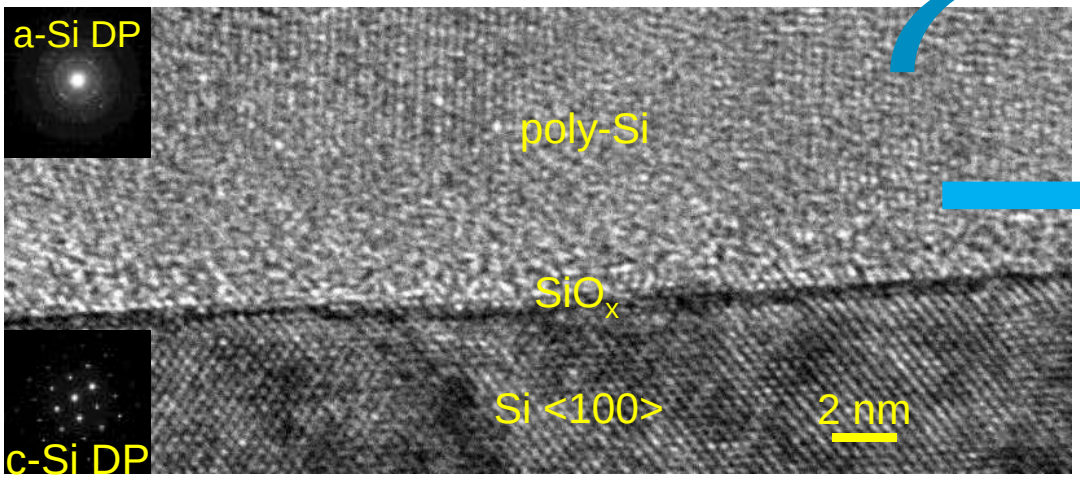




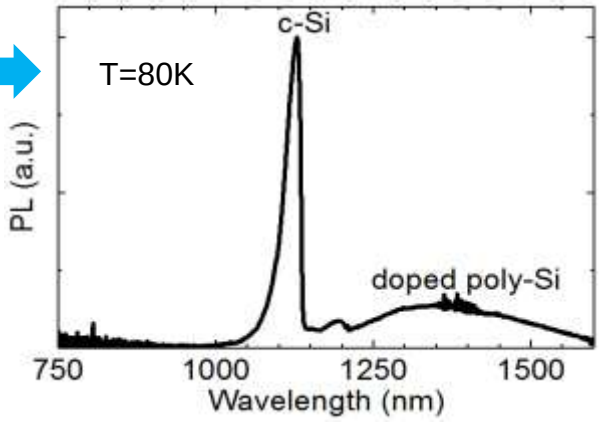
Even 1.3nm oxide layer can block carriers from a-Si:H films

What we have know so far…

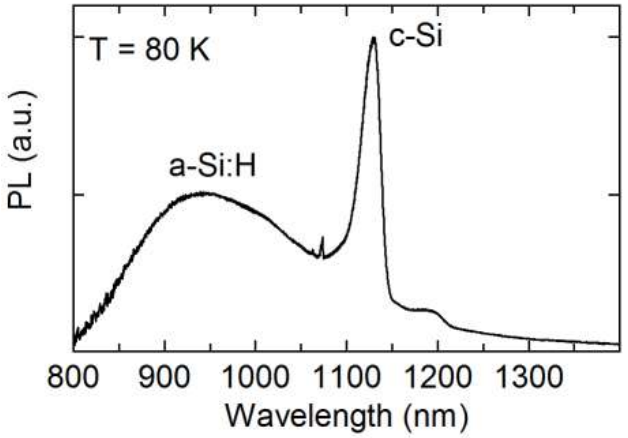
1)



both amorphous and crystalline phases



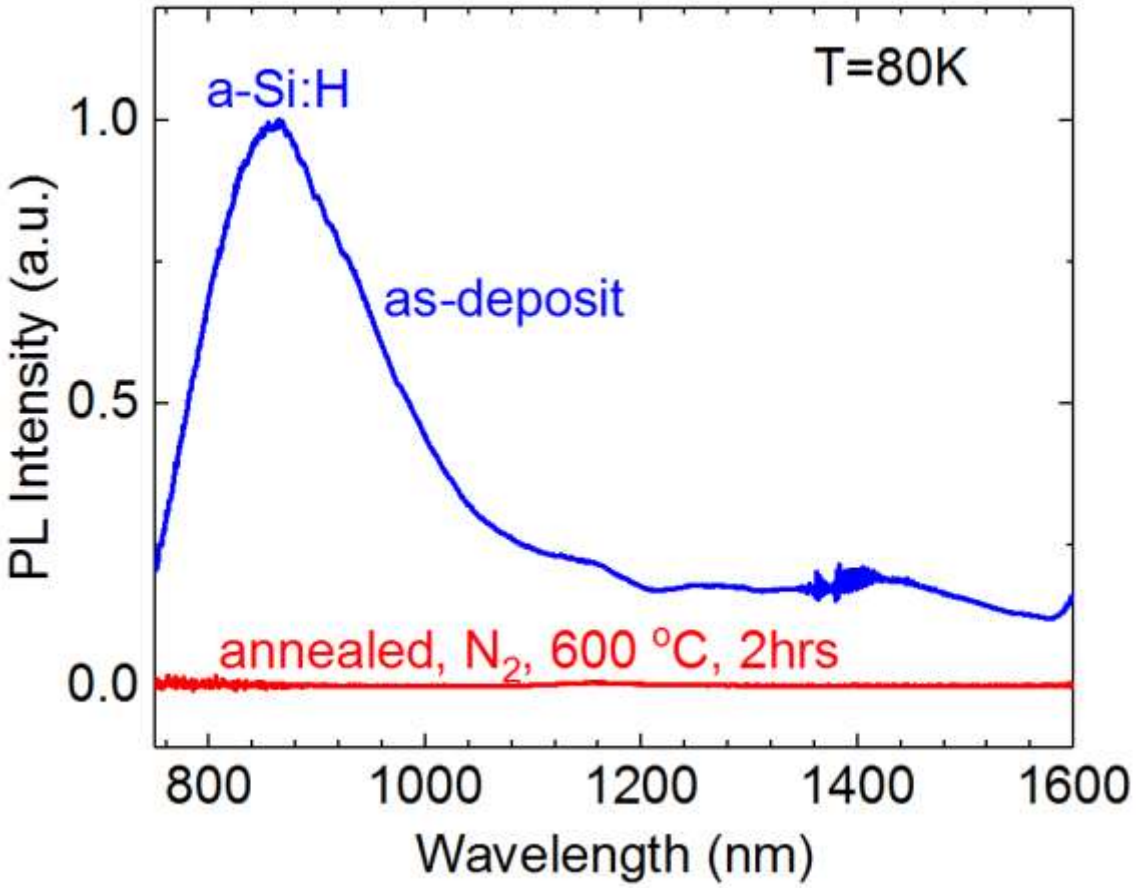
2) a-Si:H films have a strong PL emission



Why didn't we see the a-Si:H peak from poly-Si films?

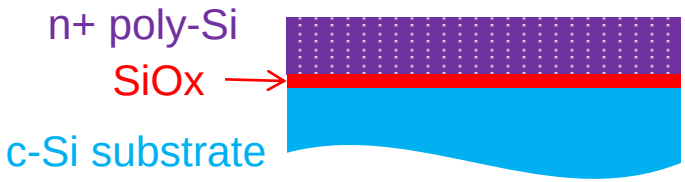
Foundation for the next application…

PL emission from PECVD a-Si:H

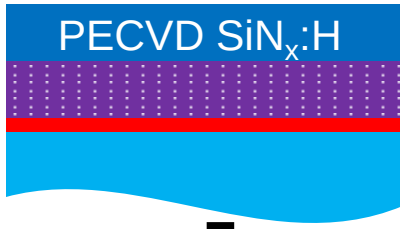


- **Annealed → H escapes the film → un-hydrogenated a-Si**
- **Phosphorus diffusion (>800 °C) → no hydrogen in the film → no a-Si:H peak**

Hydrogenation in doped poly-Si films (1/2)

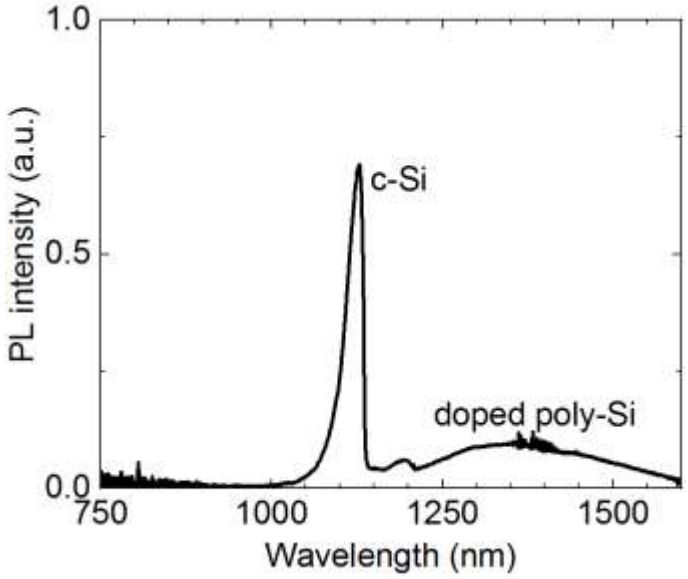


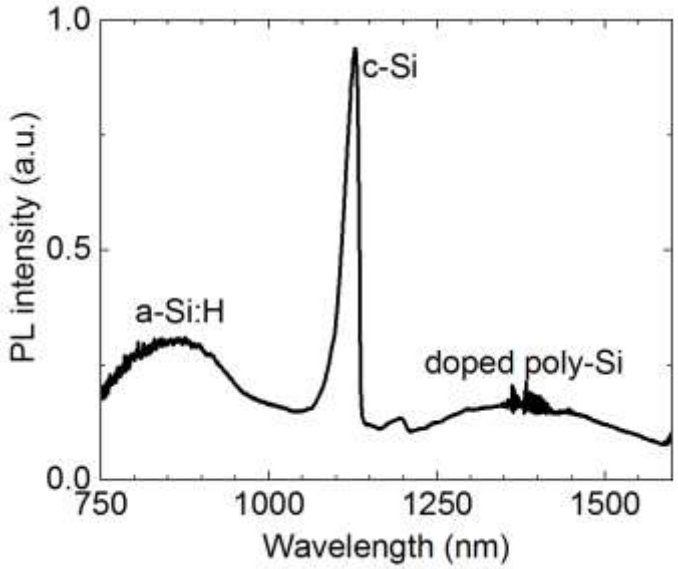
PECVD



+ FGA
500 °C, 30m

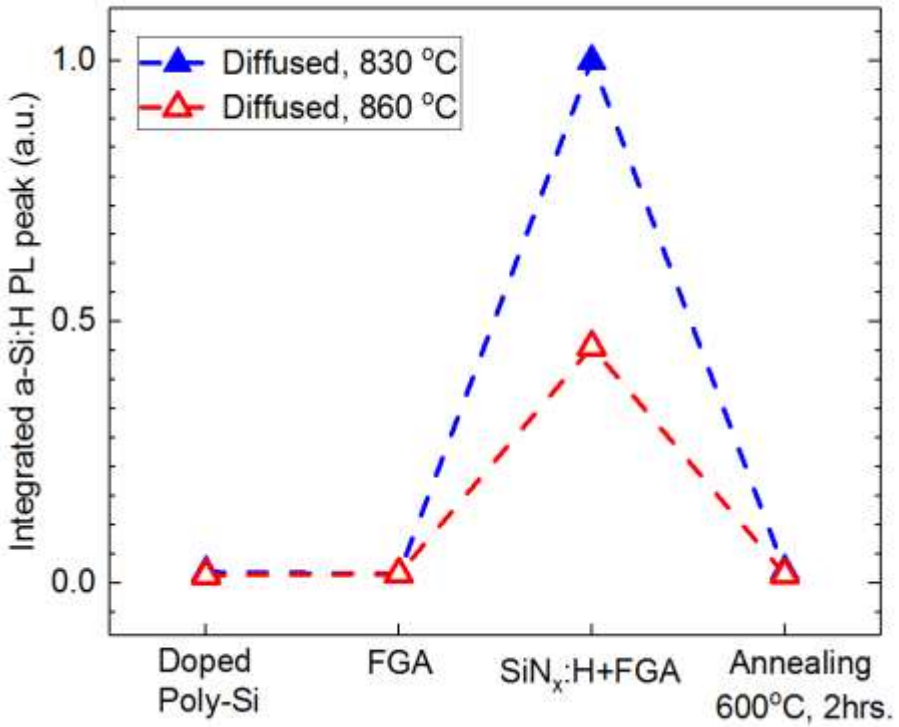
Remove SiNx





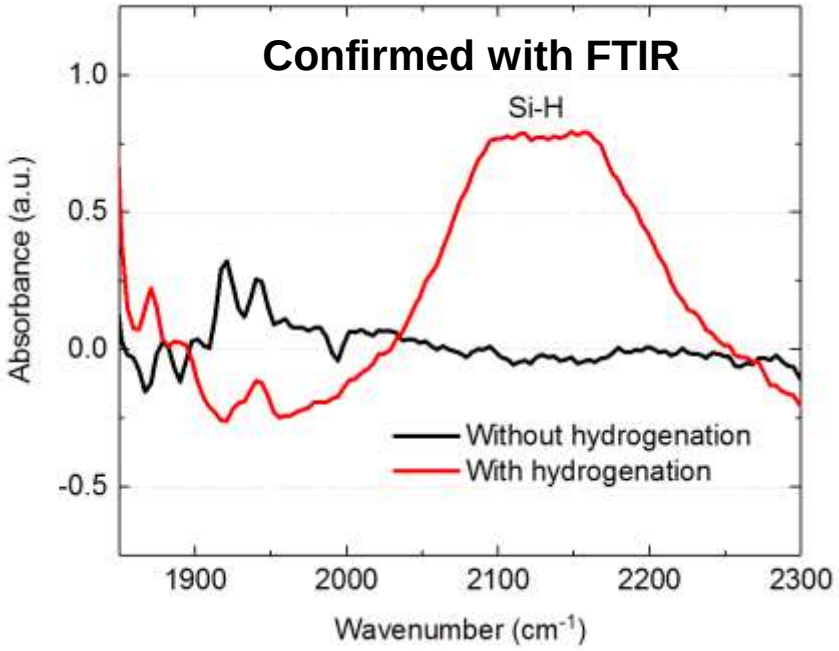
We can introduce H atoms into doped poly-Si films

Hydrogenation in doped poly-Si films (2/2)



- **We can manipulate the presence of H in poly-Si films**

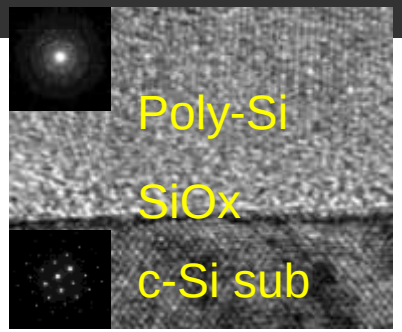
- **Clear Si-H bonds from FTIR**



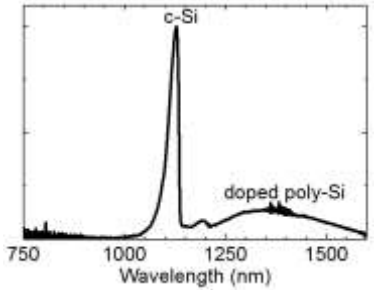
Summary

P-doped poly-Si films:

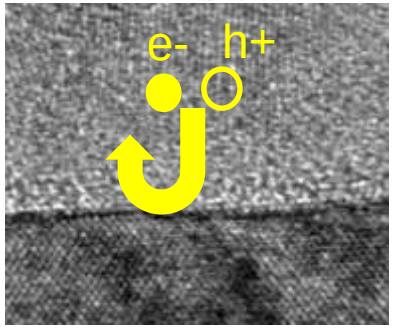
- Amorphous and crystalline phases



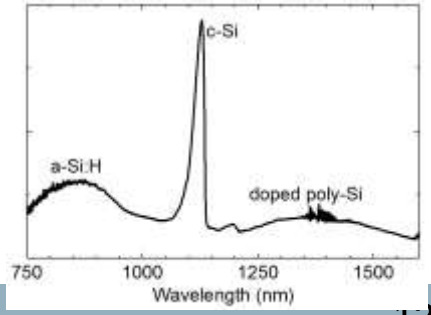
- Strong sub-bandgap PL



- No carrier coupling from these films in practical solar cells



- We can manipulate the presence of H in poly-Si films



Acknowledgement

ARENA
Australian Government
Australian Renewable Energy Agency

ACAP
Australian Centre for Advanced Photovoltaics

ANFF
Australian National Fabrication Facilities

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

UNSW
THE UNIVERSITY OF NEW SOUTH WALES

U.S. DEPARTMENT OF ENERGY

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NREL: Harvey Guthrey, Mowafak Al-Jassim (TEM)