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.

poly-Si films also absorb light $\rightarrow$ could yield PL signal
Doped poly-Si films:
+ Formation and microscopic structures
+ Luminescence

Applications of poly-Si luminescence
+ Carrier transport
+ Hydrogenation effects
Formation and microscopic structures

1.3nm SiOx

PECVD

100nm a-Si:H

P-diffused
>800 °C

n+ poly-Si

e- O

TEM image

Doped poly-Si films contain both amorphous and crystalline phases

a-Si DP

poly-Si

SiOx

Si <100>

2 nm
PL from doped poly-Si films

PL (1250-1500nm) is from radiative defects in doped poly-Si films
Investigating carrier transport (1/2)

- n+ poly-Si
- SiOx
- c-Si substrate

No carrier coupling from doped poly-Si films
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) SiO$_x$ poly-Si

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

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

We can introduce H atoms into doped poly-Si films
Hydrogenation in doped poly-Si films (2/2)

- Clear Si-H bonds from FTIR
- We can manipulate the presence of H in poly-Si films

Confirmed with FTIR
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
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