Temperature Dependence of Optical Absorption in Silicon from Photoluminescence

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Background

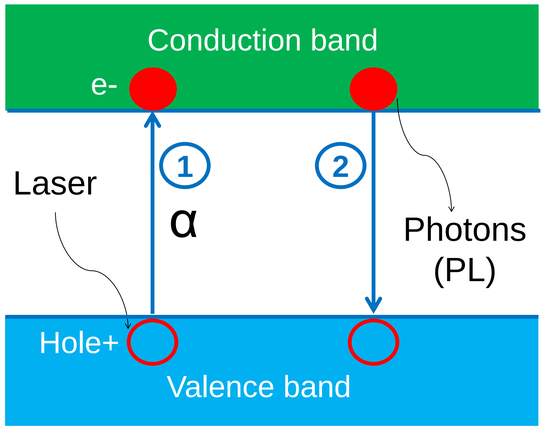

Fig. 1: illustration of photoluminescence phenomenon

1 Electrons are excited into conduction band
2 Electrons fall back into valence band and emit photons

Why does the absorption coefficient matter?

Operation of silicon solar cells is based on the excited electrons in the conduction band. These electrons are the result of optical absorption. Thus, the **absorption coefficient α** is the most direct parameter for characterisation models.

Why the photoluminescence (PL) method?

Extremely sensitive → allow to accurately determine extremely low values of **α** - several orders of magnitude smaller than the conventional method (transmission and reflection measurement) [1].

REFERENCE:
[1] G. G. MacFarlane, T. P. MacLean, J. E. Quarrington, and V. Roberts, Phys. Rev. 111, 1245 (1958).

This work has been supported by the Australian Renewable Energy Agency (ARENA) and the Australian Research Council (ARC).

How does the PL spectroscopy system work?

- Laser excites electrons in the sample via **process 1**.
- Sample emits photons via **process 2**.
- Photons are guided into a monochromator to filter out only desired wavelengths, which are captured by a detector.
- The captured spectra are analysed to extract **α**.

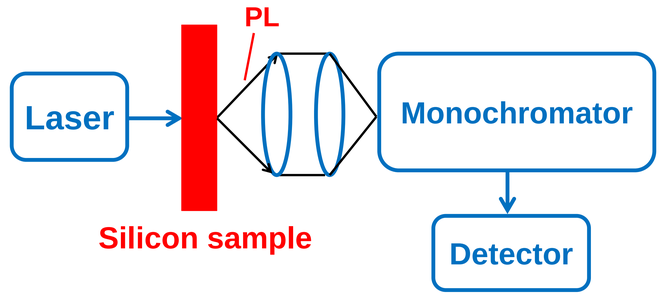

Fig. 2: diagram of PL spectroscopy system

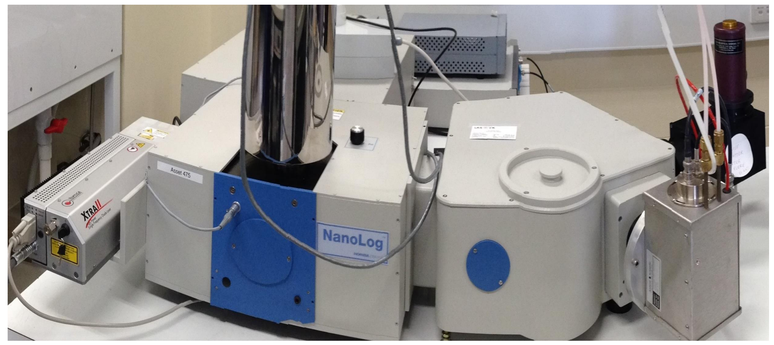

Fig. 3: PL spectroscopy system in ANU solar lab

Results

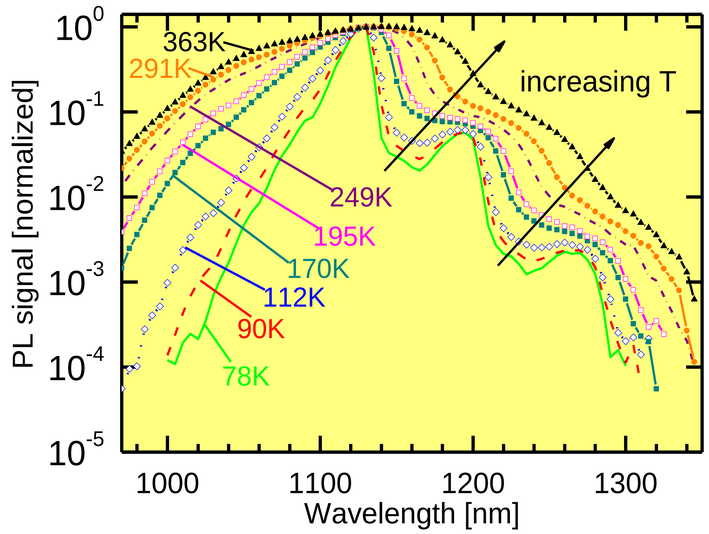

Fig. 4: PL spectra captured at different temperatures

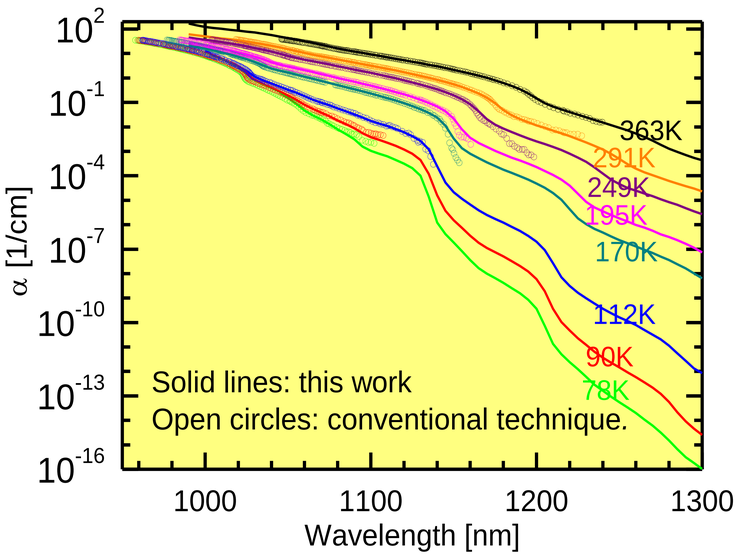

Fig. 5: absorption coefficient at different temperatures

We have established:

- **Complete dataset of absorption coefficient α in working temperature range of silicon solar cells**
- **Formula to describe temperature dependence of absorption coefficient α**

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