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► **To cite this version:**

Lipin Chen, Oliver Skibitzki, Yoan Léger, Christophe Levallois, Rozenn Piron, et al.. Photoluminescence of 2D-vertical In-rich APBs embedded in InGaP/SiGe/Si. 20th International Conference on Molecular-Beam Epitaxy (ICMBE 2018), Sep 2018, Shanghai, China. 2018. hal-01909074v2

HAL Id: hal-01909074

<https://hal.science/hal-01909074v2>

Submitted on 19 Jun 2020

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Photoluminescence of 2D-vertical In-rich APBs embedded in InGaP/SiGe/Si

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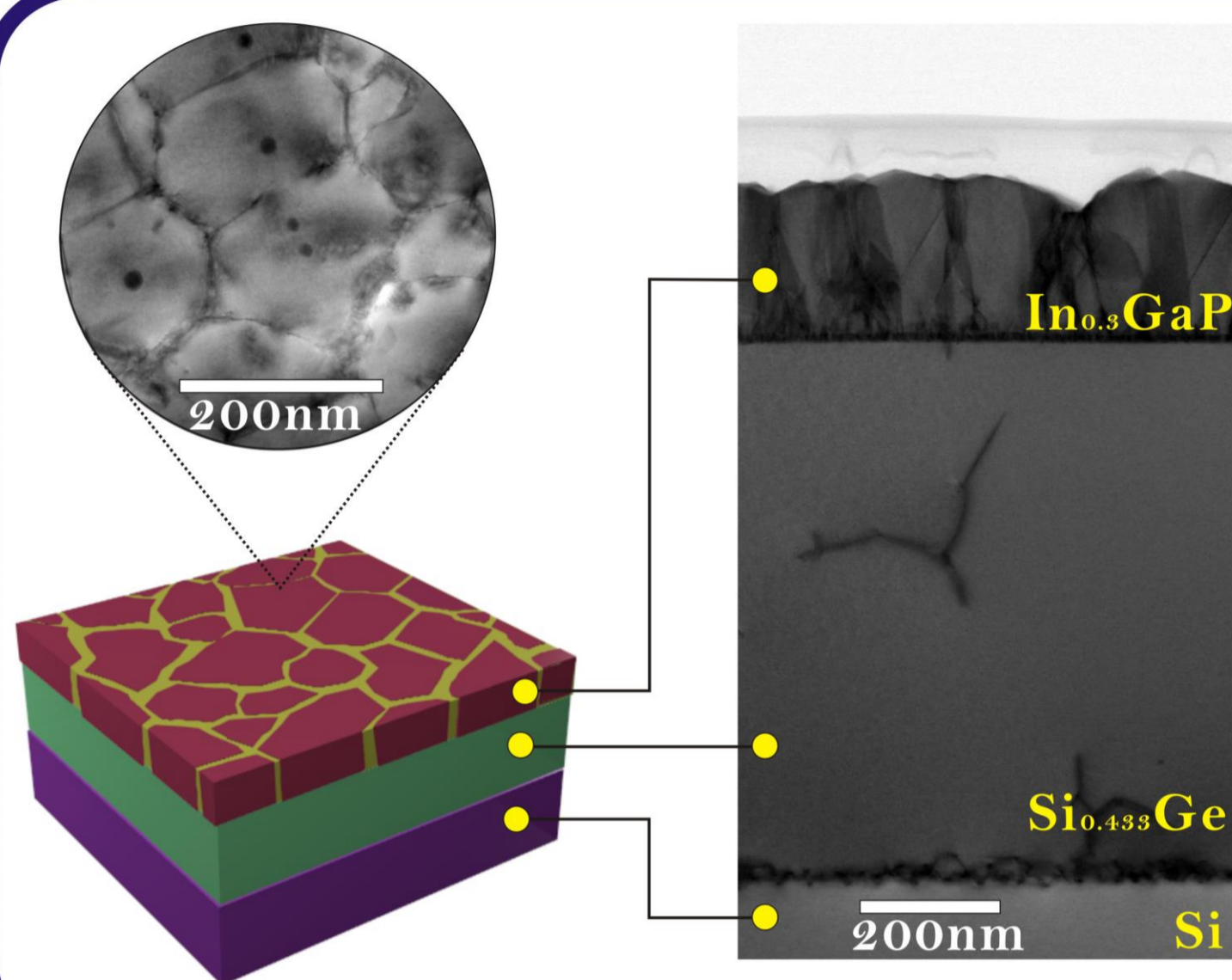
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Introduction

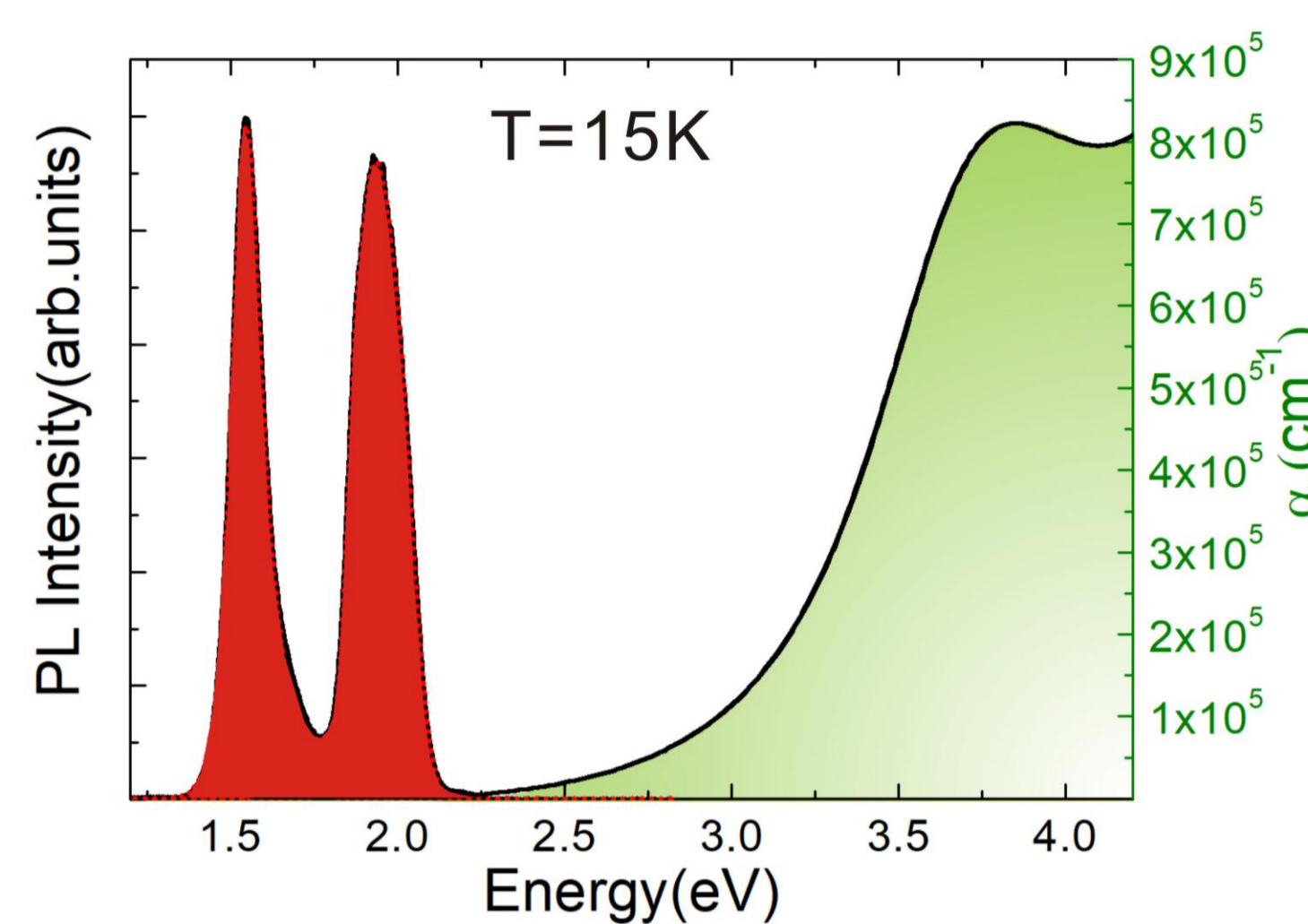
Heterogeneous epitaxy of III-V compounds with superior optical properties onto Si substrate very close to the III-V/Si hetero-interface becomes major concern for Si photonics. Antiphase boundaries (APB) are generated during heteroepitaxy, have always been considered as detrimental defects for optical devices. However, in this work we provided a new insight into the APBs which are involved in an efficient luminescence process.

TEM micrographs



- InGaP active layer contains many antiphase boundaries (APBs)
- Some quantum dots (QDs) observed on the surface

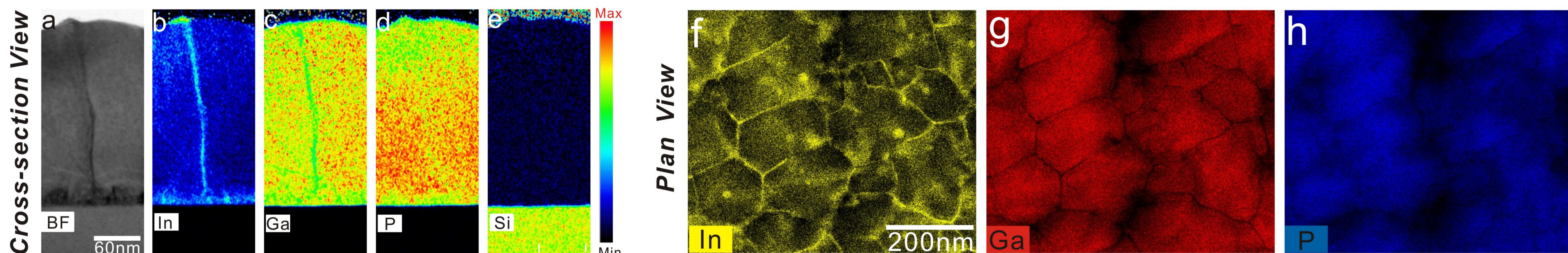
PL and optical absorption spectra



- Two transitions detected on the PL spectrum
- The onset of the absorption is around the high energy peak i.e. it is likely related to band to band recombination

EDX elemental mapping

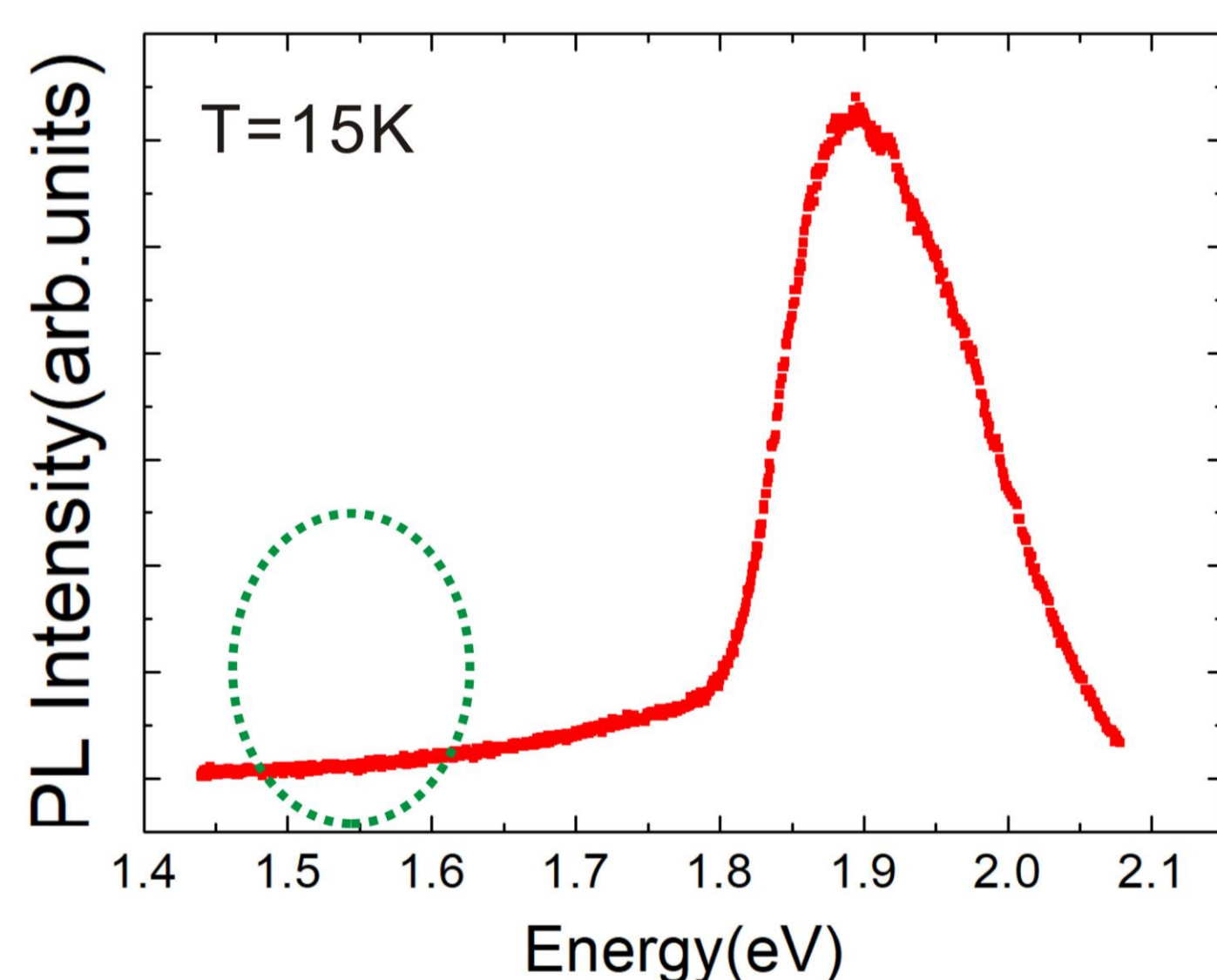
- Two kinds of nanostructures: pure InP surface QDs and In-rich APBs



Sample after CMP

SEM images of as-grown sample and sample after chemical mechanical polishing (CMP)

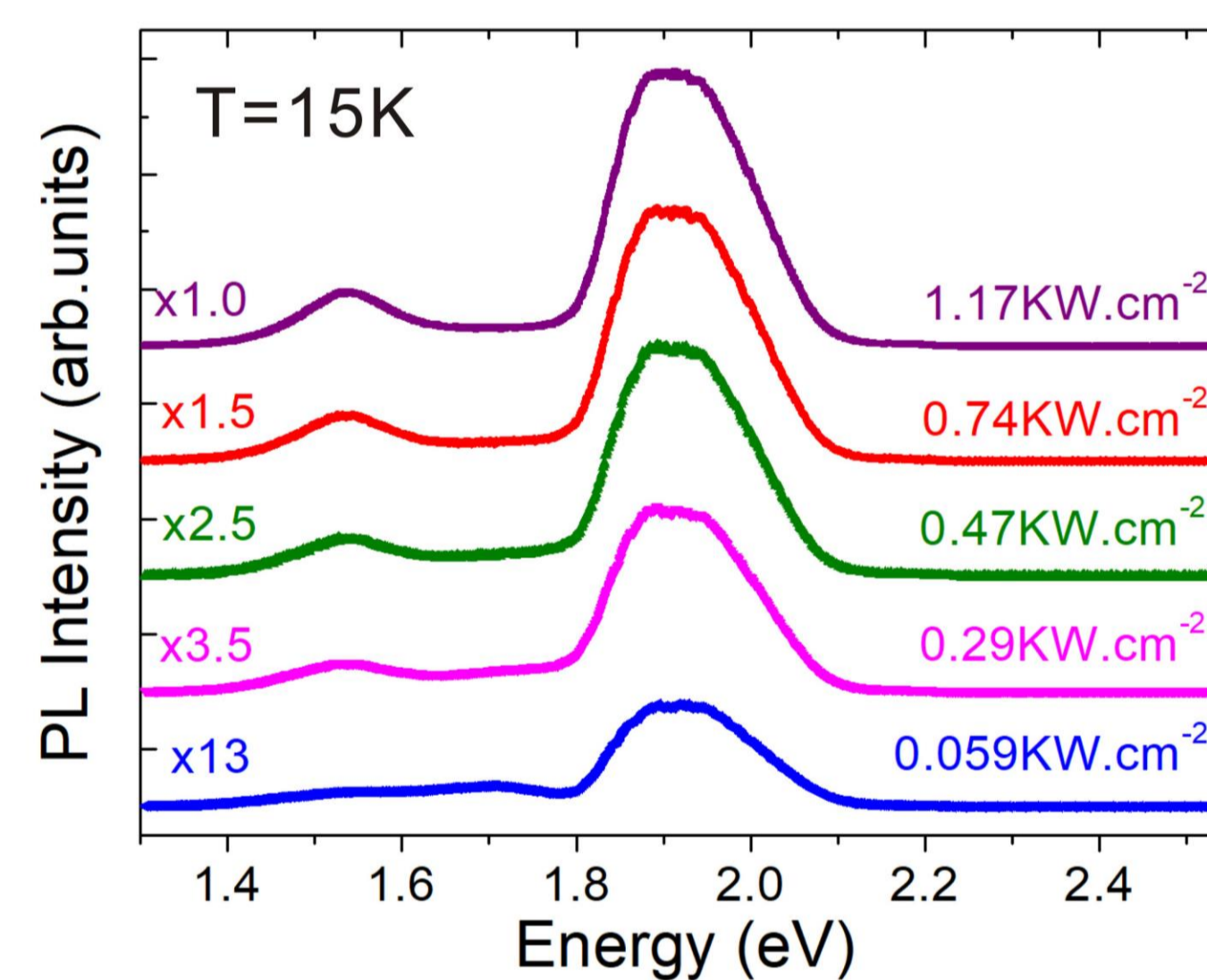
- Surface QDs are almost removed after CMP



PL after CMP process

- Low energy peak disappears
- ➔ Low energy peak comes from the surface InP QDs.

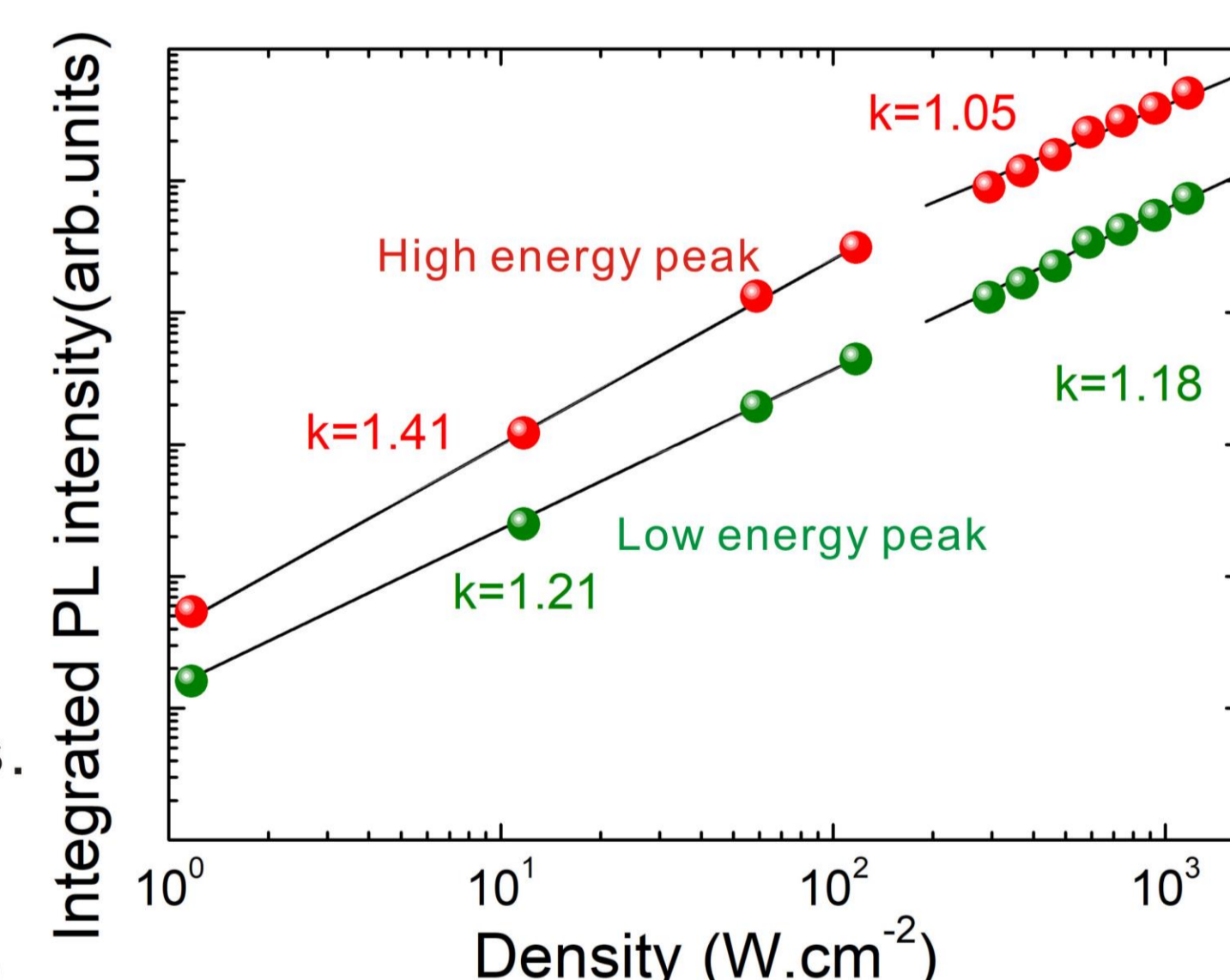
Power-dependent PL



Steady-state PL with saturated InP QDs

Integrated PL intensity versus power density

- High energy peak shows superlinear to linear power-dependent behaviour
- ➔ Typical feature of excitation process via exciton bounded to neutral acceptors or donors.



He, H. et al. Nature Communications, 7(2016).
Schmidt, T.K. et al. Physical Review B, 45(1992).

Physical mechanism proposed for the high energy PL peak

- In APB spacing, many acceptor-like states shown due to III-III bonds in the band gap
- Excitons bounded to neutral APBs

Tea, E. et al. Journal of Applied Physics, 115(2014).

Conclusions

- ➔ Preferential incorporation of In atoms on APBs is evidenced.
- ➔ Low energy peak is proved to come from the surface InP QDs.
- ➔ High energy peak results from localized excitons bounded around the neutralized In-rich APBs.