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

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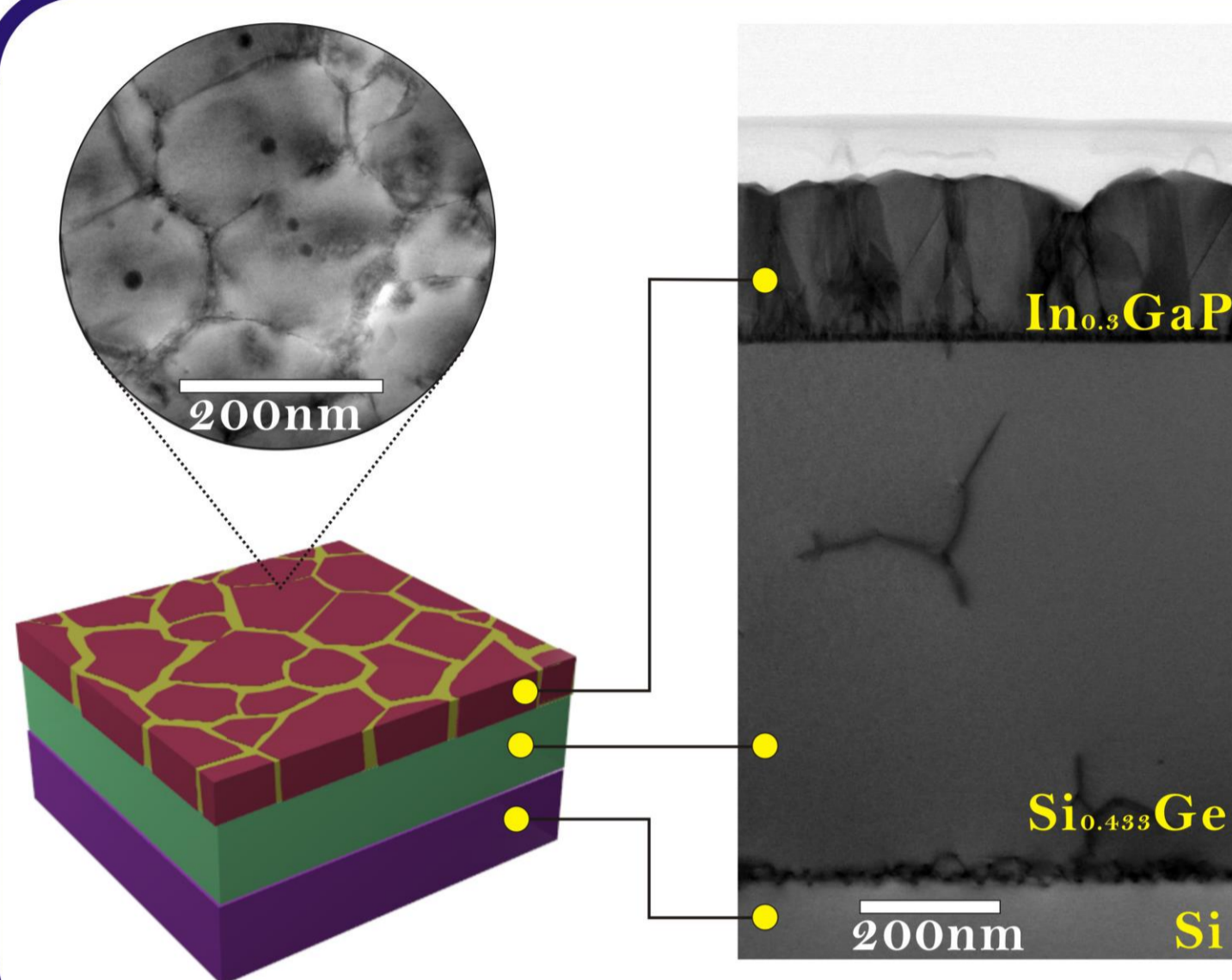
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Introduction

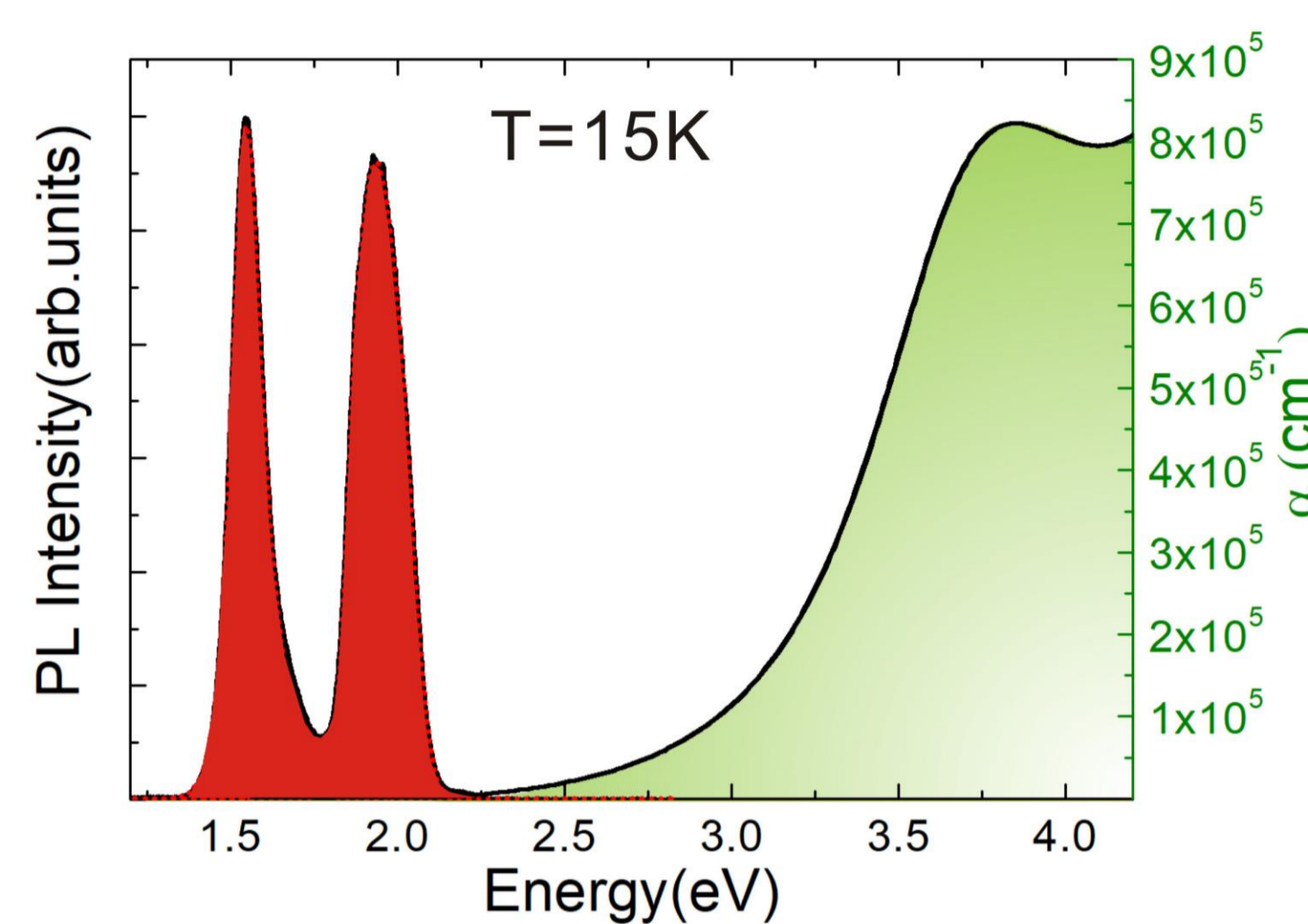
Heterogeneous epitaxy of III-V compounds with superior optical properties onto Si substrate very close to the III-V/Si hetero-interface becomes major concern for Si photonics. Antiphase boundaries (APB) are generated during heteroepitaxy, have always been considered as detrimental defects for optical 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

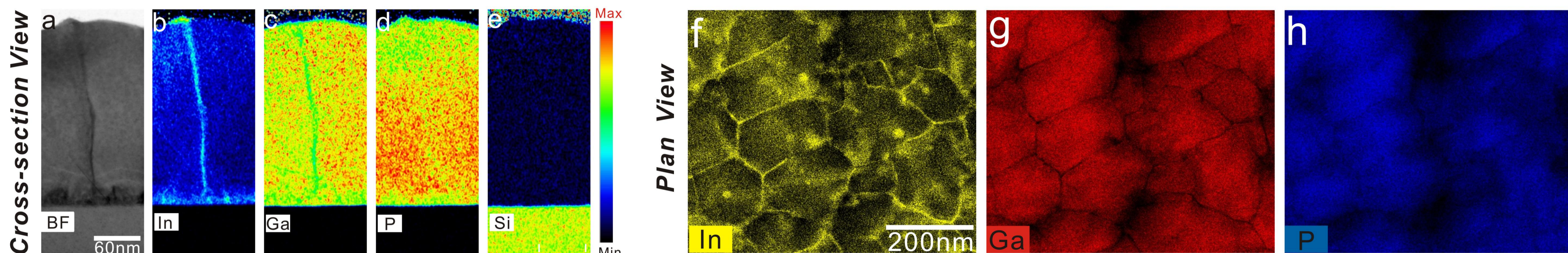
PL and optical absorption spectra



- 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

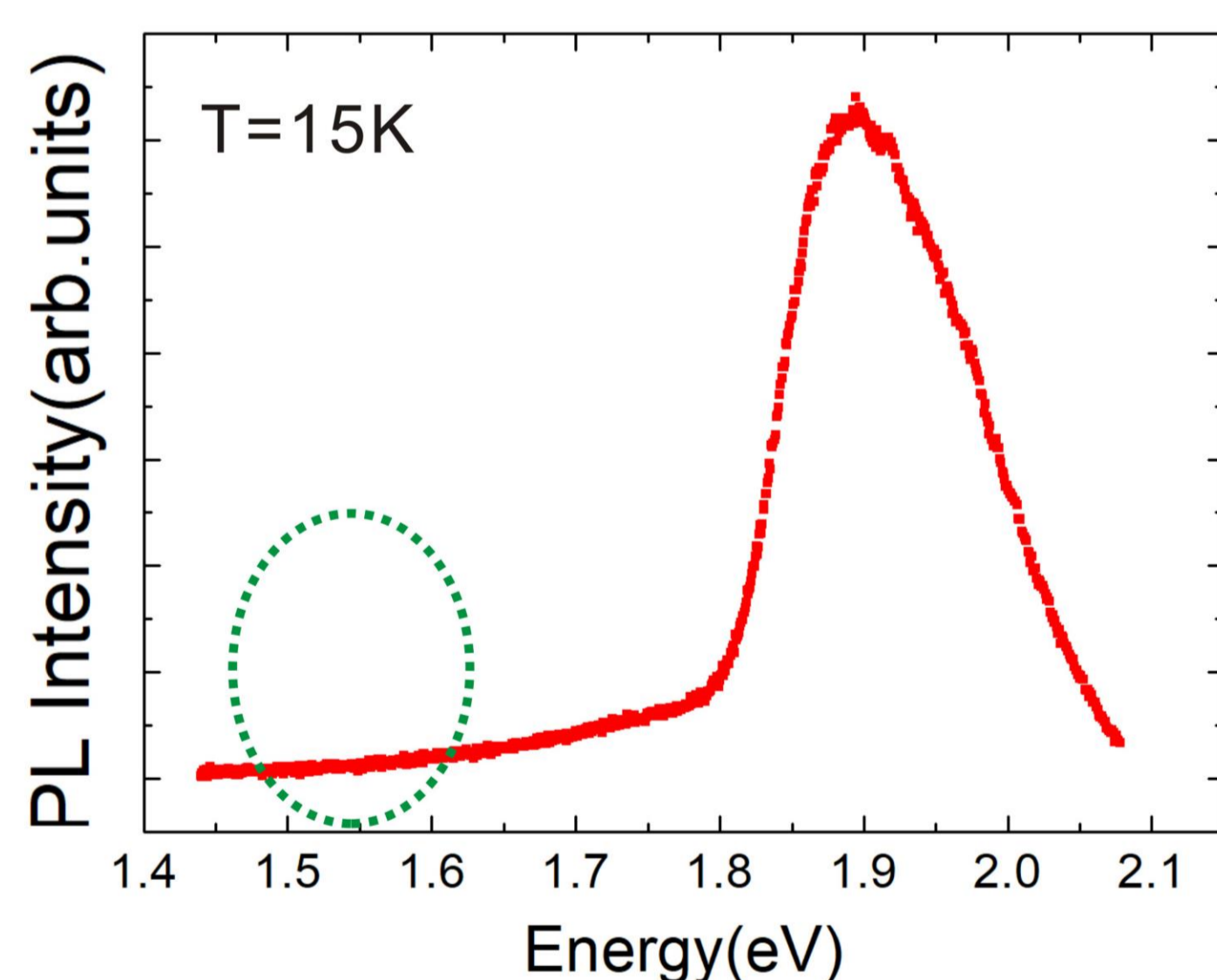
- Two kinds of nanostructures: pure InP surface QDs and In-rich APBs



Sample after CMP

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

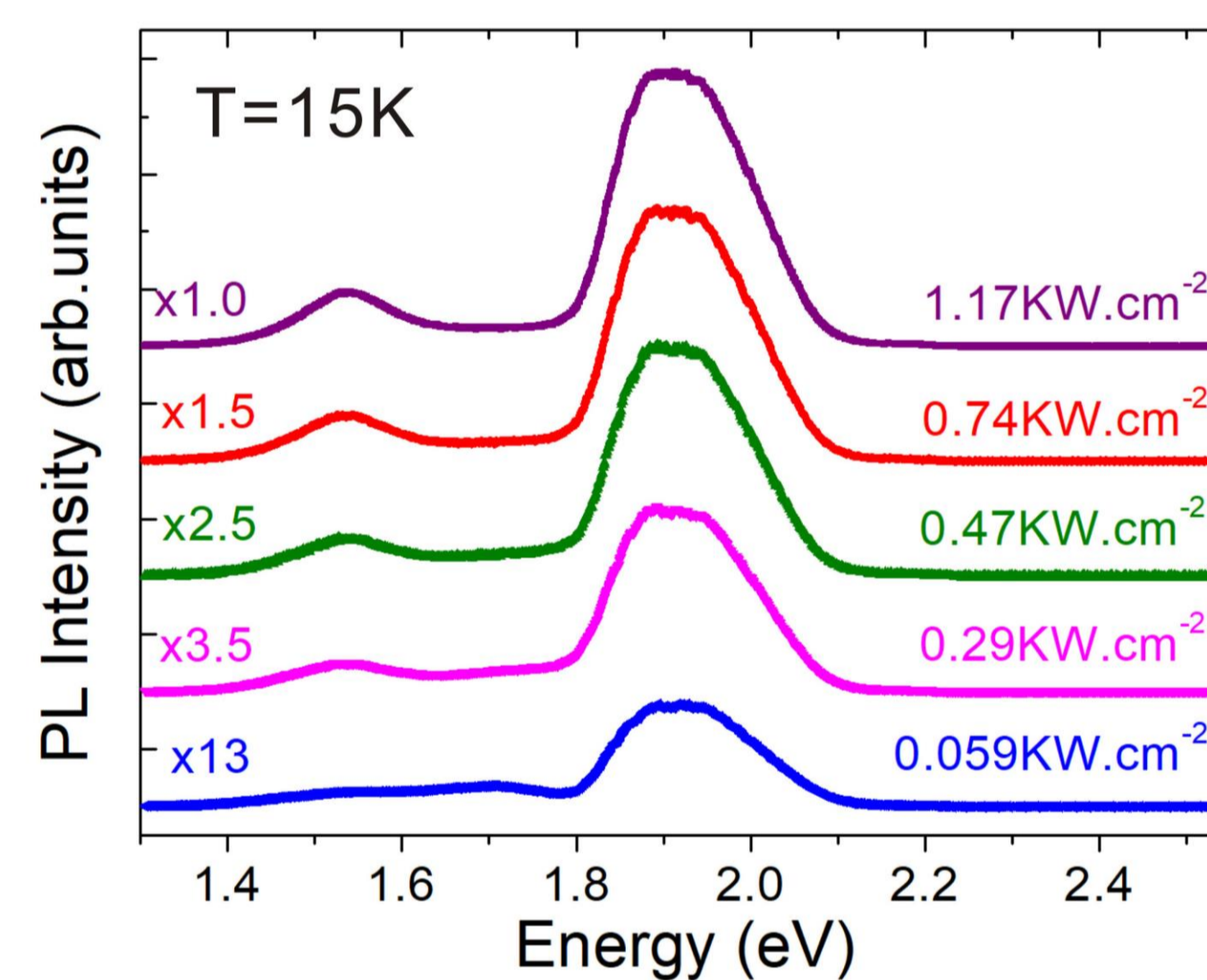
- Surface QDs are almost removed after CMP



PL after CMP process

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

Power-dependent PL

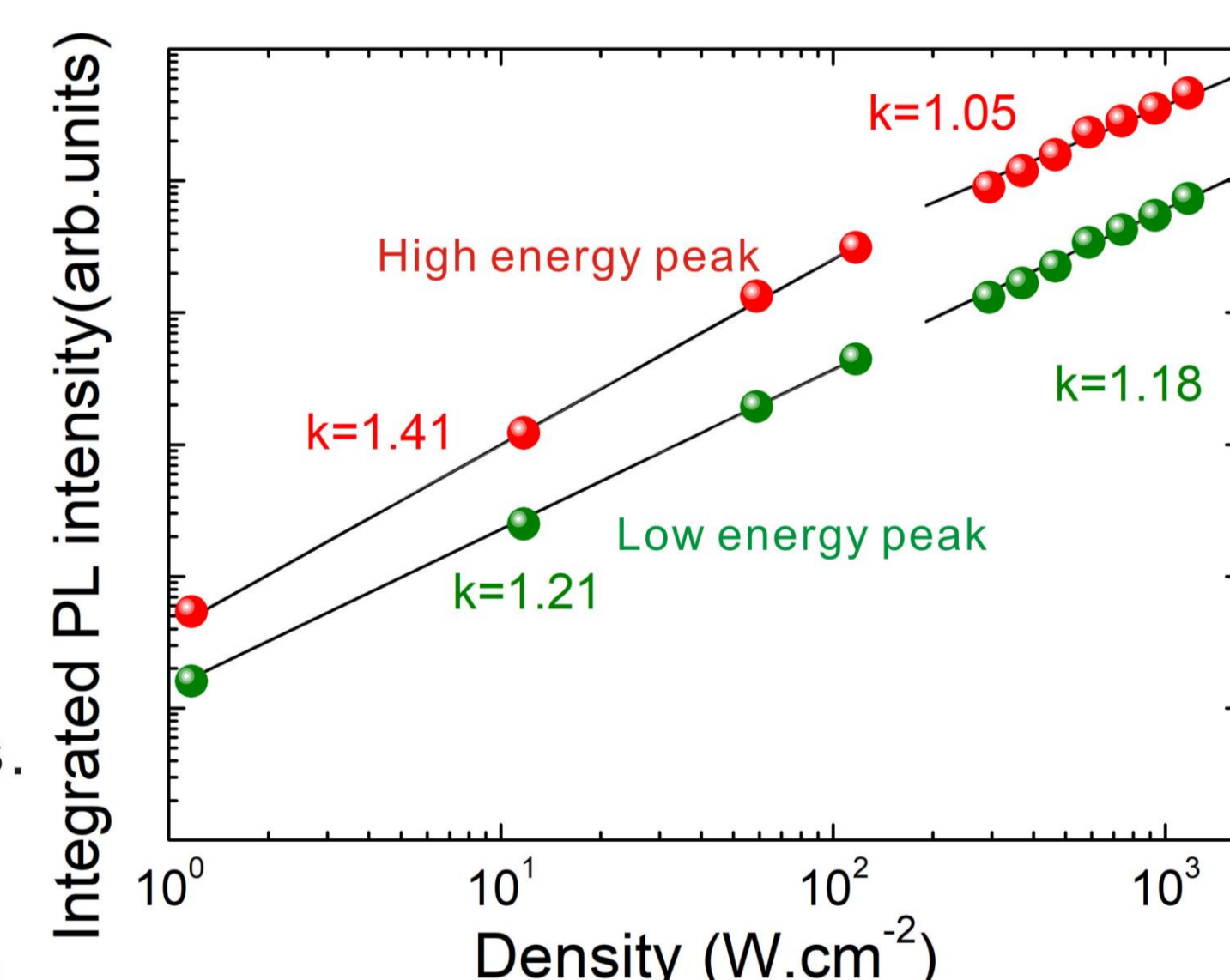


Integrated PL intensity versus power density

- 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).

Steady-state PL with saturated InP QDs



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.