

Electrical Characterization of InAs QDs based Devices



Chatdanai Lumdee

Advisor
Assoc. Prof. Songphol Kanjanachuchai, Ph.D.

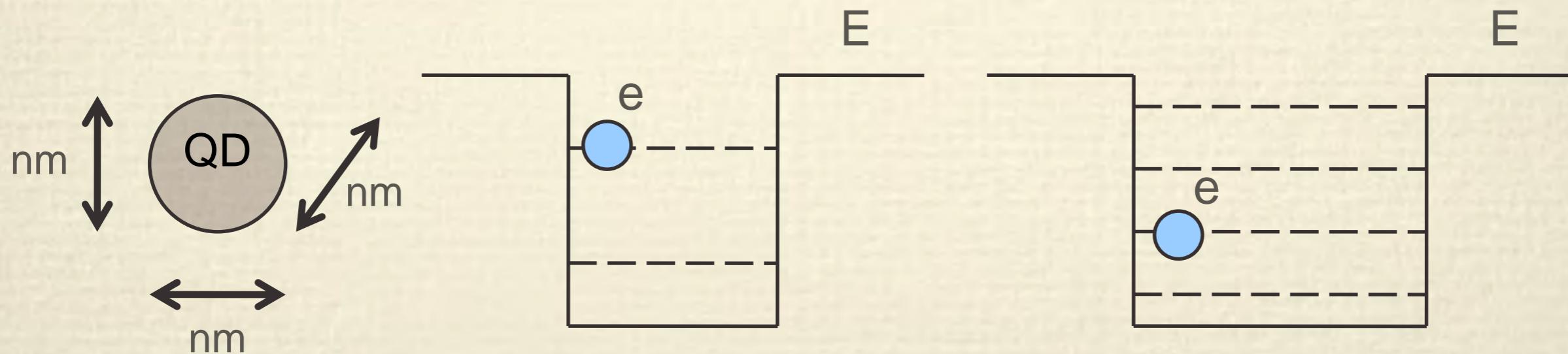
International School of Engineering, Chulalongkorn University
May, 2010

Outline

- ❖ Introduction
- ❖ QDMs Samples
- ❖ Experiments
- ❖ Results and Discussion
- ❖ Conclusion

Introduction

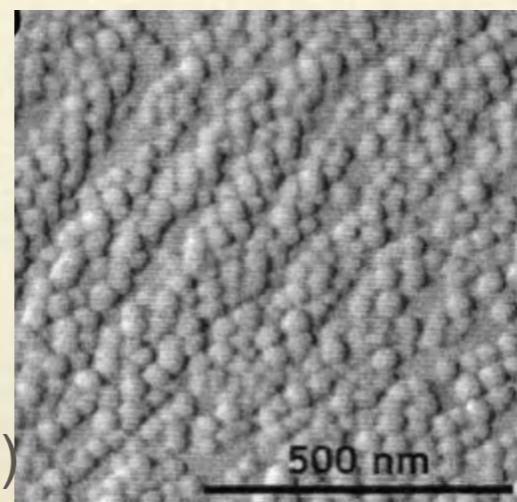
- ❖ Quantum Dots
 - ❖ 3D confinement structure
 - ❖ Discrete energy band
 - ❖ The discretization is size dependent



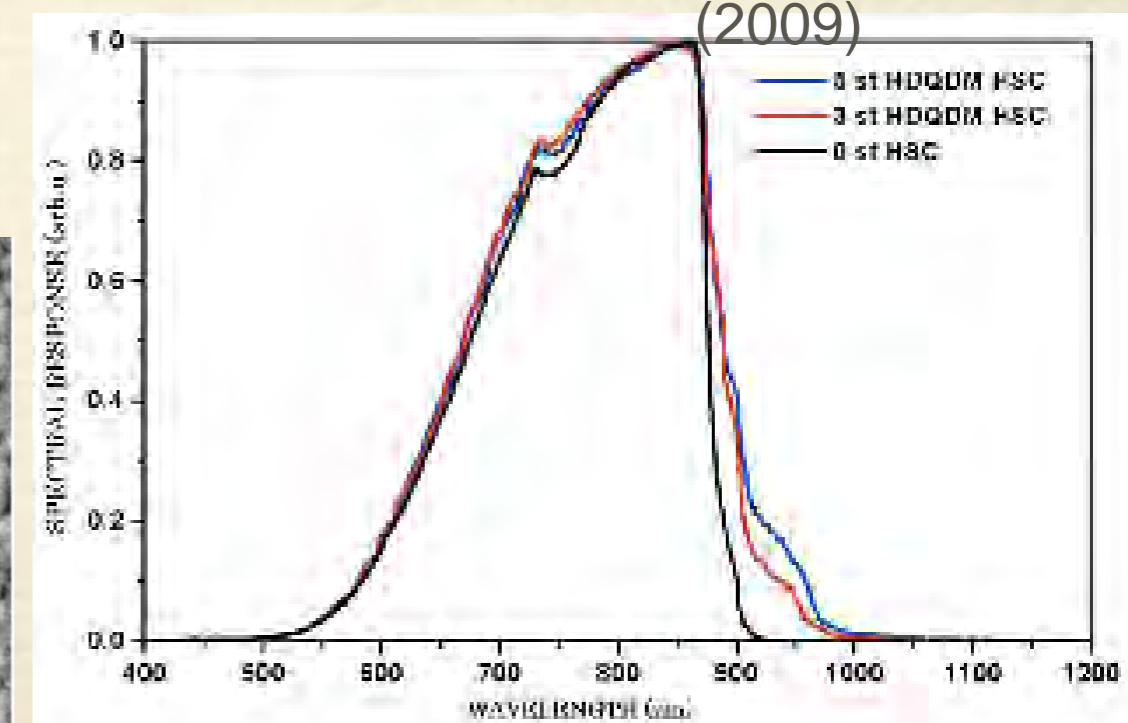
Introduction

- ❖ Quantum Dots based Devices
 - ❖ Modified by QDs properties
 - ❖ Better performance
 - ❖ Wide range of applications
 - ❖ ex. photovoltaic

Swe et al. (2008)



Laouthaiwattana et al.
(2009)

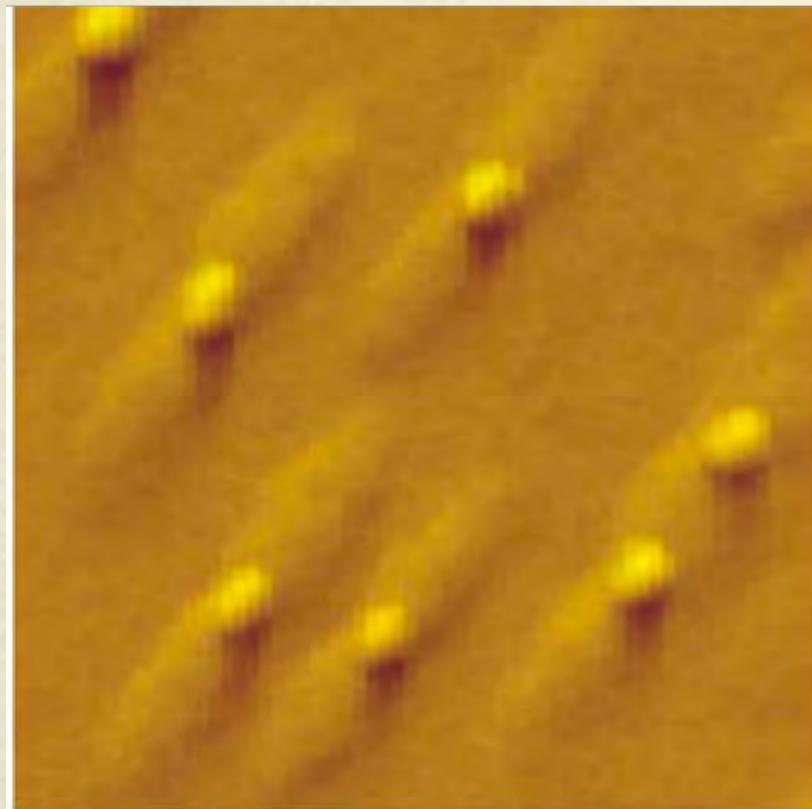


Introduction

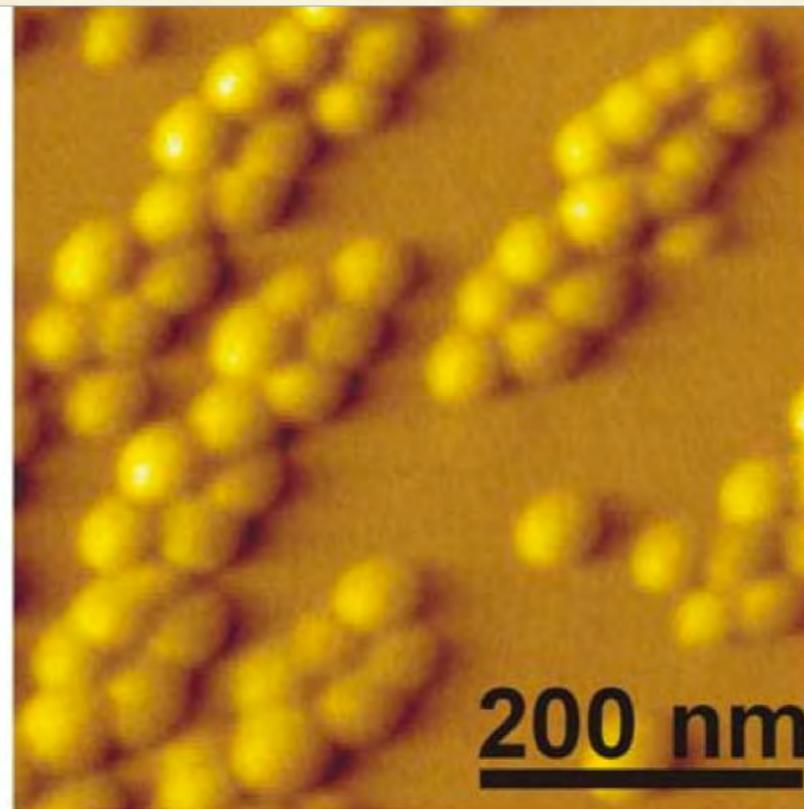
- ❖ Quantum Dot Molecules (QDMs)
 - ❖ Multi-layer of QDs
 - ❖ Thin-cap and regrowth process
 - ❖ Intermediate layer is very thin
 - ❖ Electrical couple of electron between QDs
 - ❖ The upper layer is influenced by its lowers
 - ❖ Specific pattern is formed

Introduction

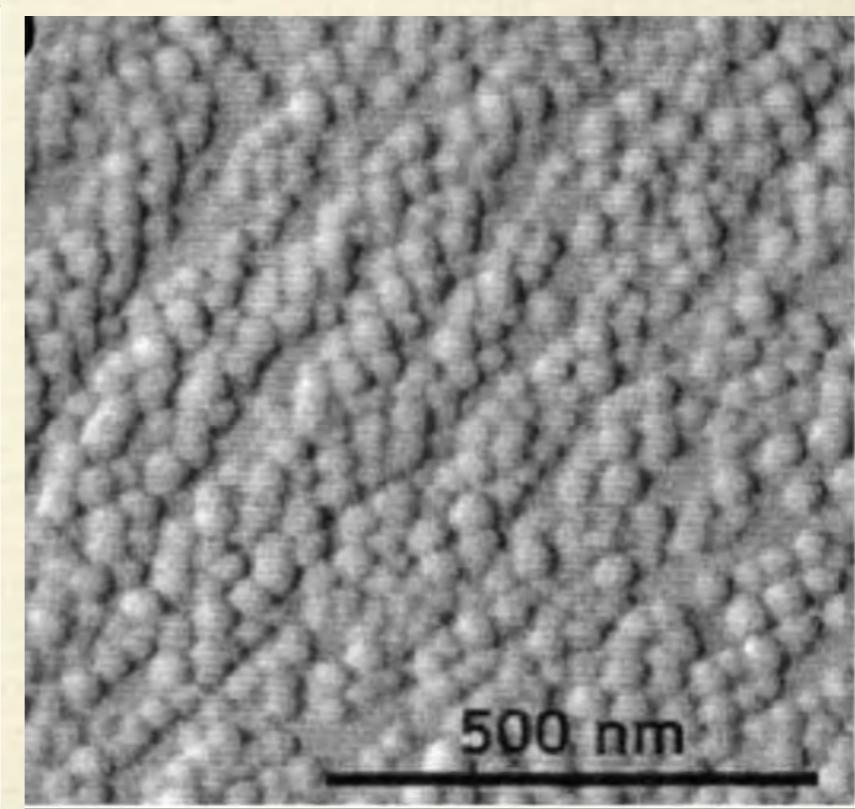
- ❖ QDMs



Suraprapapich *et al.*
(2006)



Suraprapapich *et al.*
(2006)



Swe *et al.* (2008)

Introduction

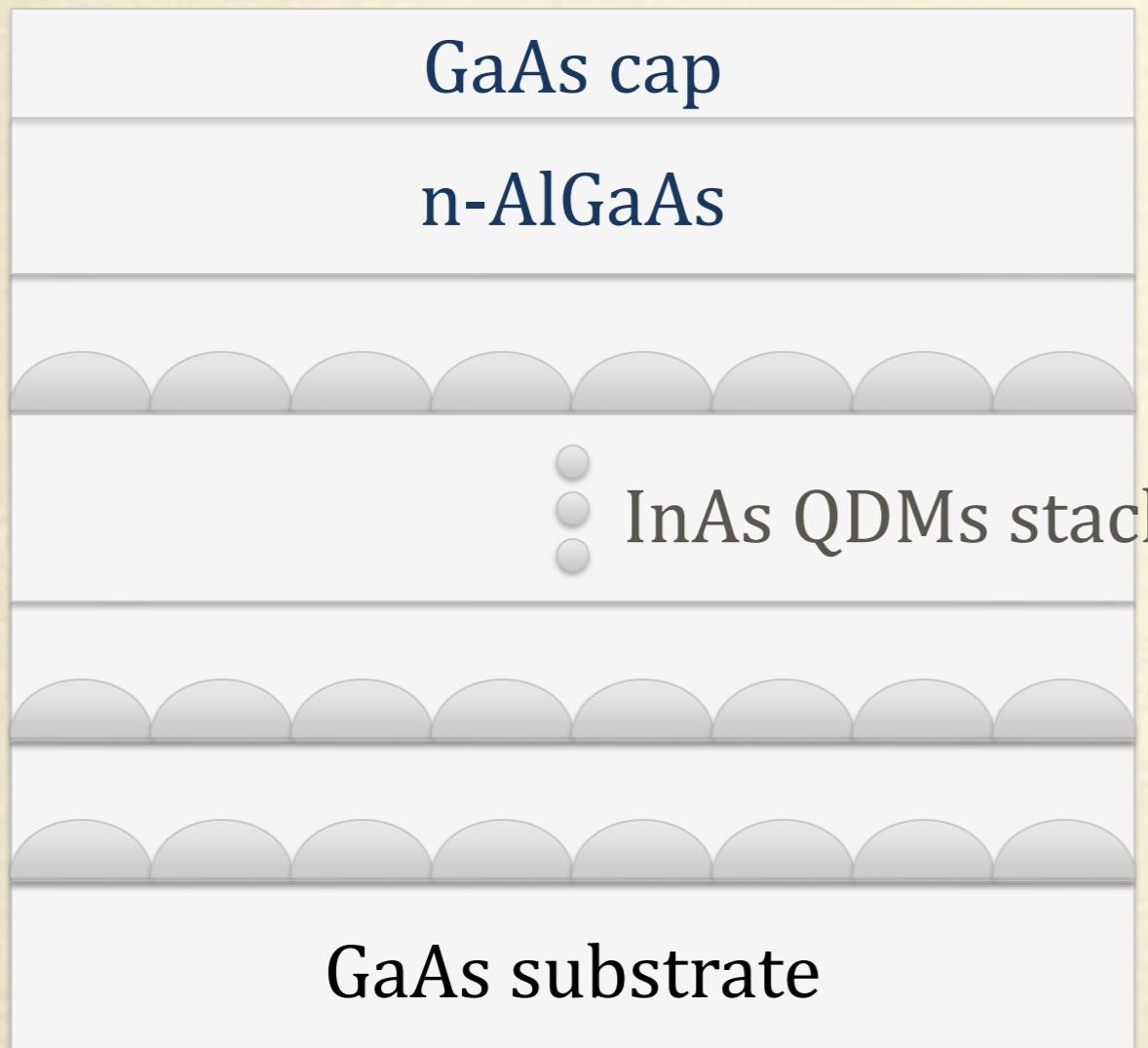
- ❖ Electrical characterization
 - ❖ IV characteristic under various condition
 - ❖ Determine how the structure reacts to a specific environment
 - ❖ An important information in understanding a current transport mechanism of the device

QDMs samples

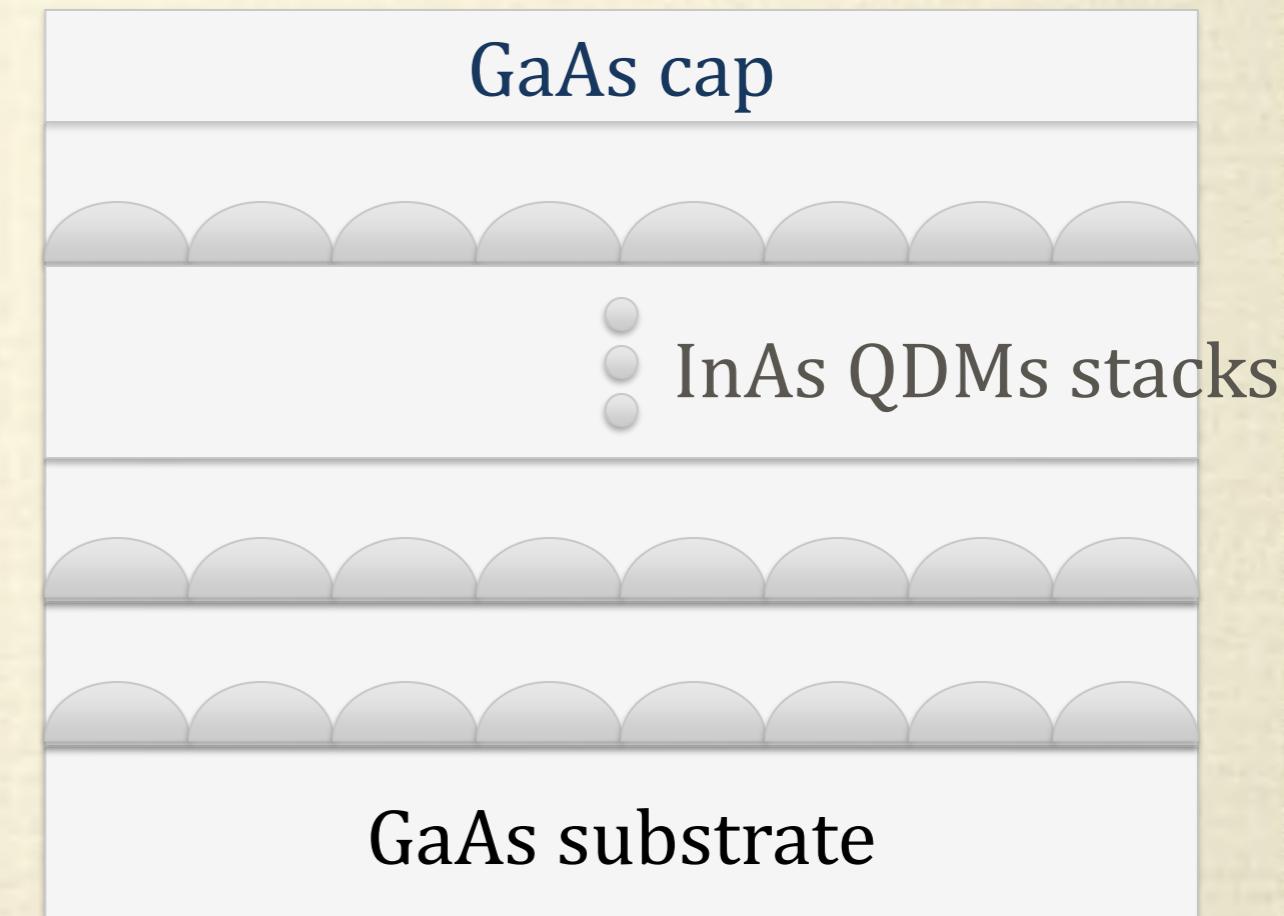
- ❖ GaAs/InAs system
- ❖ Heterostructures: 3 stacks and 5 stacks InAs QDMs
 - ❖ Effect of illumination on IV characteristics
- ❖ Schottky structures: 3 stacks and 5 stacks InAs QDMs
 - ❖ Temperature dependency of IV characteristics

QDMs samples

- ❖ All samples were growth by Riber 32P solid-source MBE under Stranski-Krastanov (SK) mode



Heterostructure



Schottky structure

QDMs samples

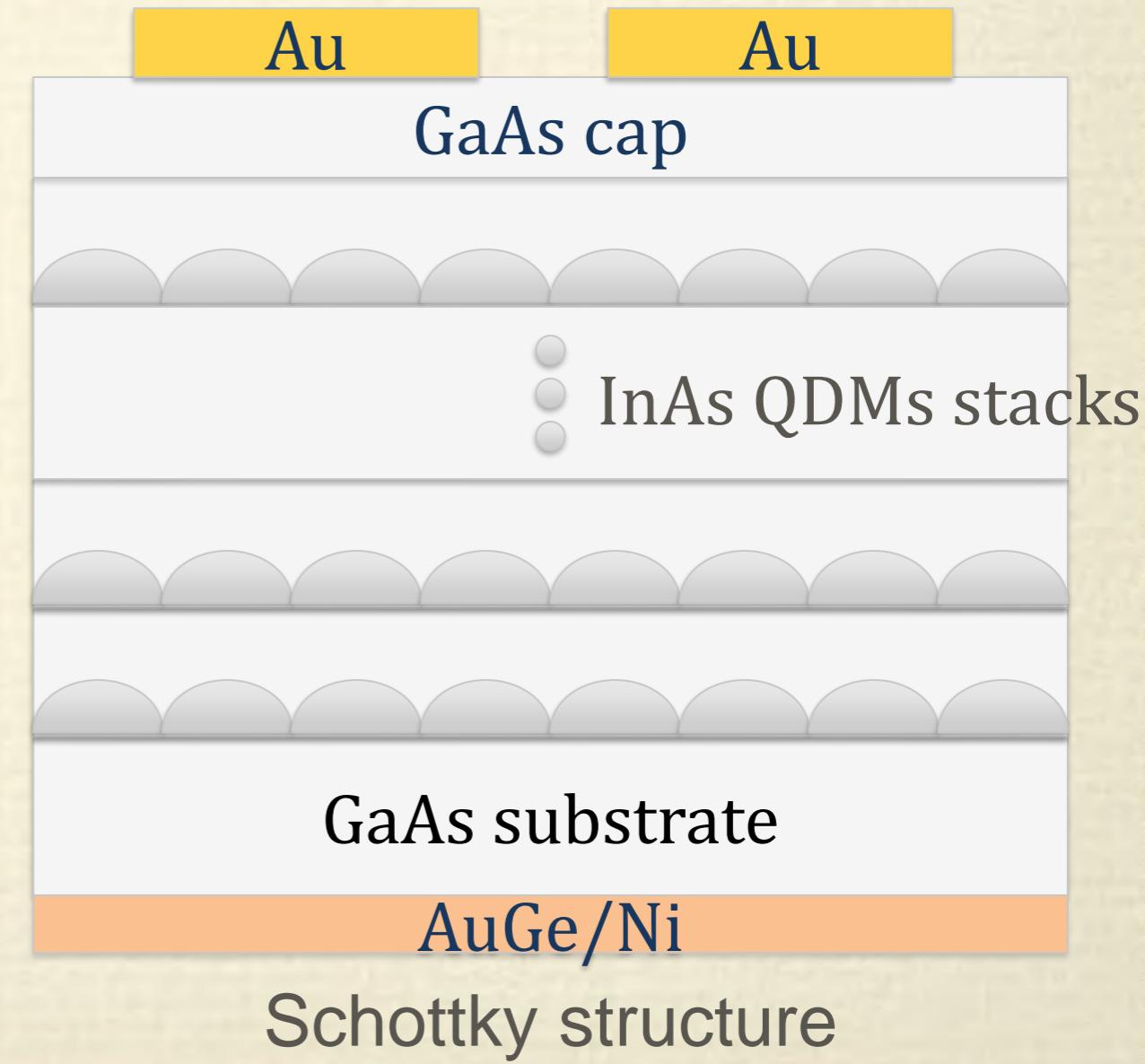
- ❖ After MBE growth → Physical vapor deposition by evaporation
 - ❖ Heterostructures
 - ❖ Substrate side: AuZn → Ohmic
 - ❖ Top side: AuGe/Ni → Ohmic
 - ❖ Schottky structures
 - ❖ Substrate side: AuGe/Ni → Ohmic
 - ❖ Top side: Au → Schottky

QDMs samples

❖ Final Structure

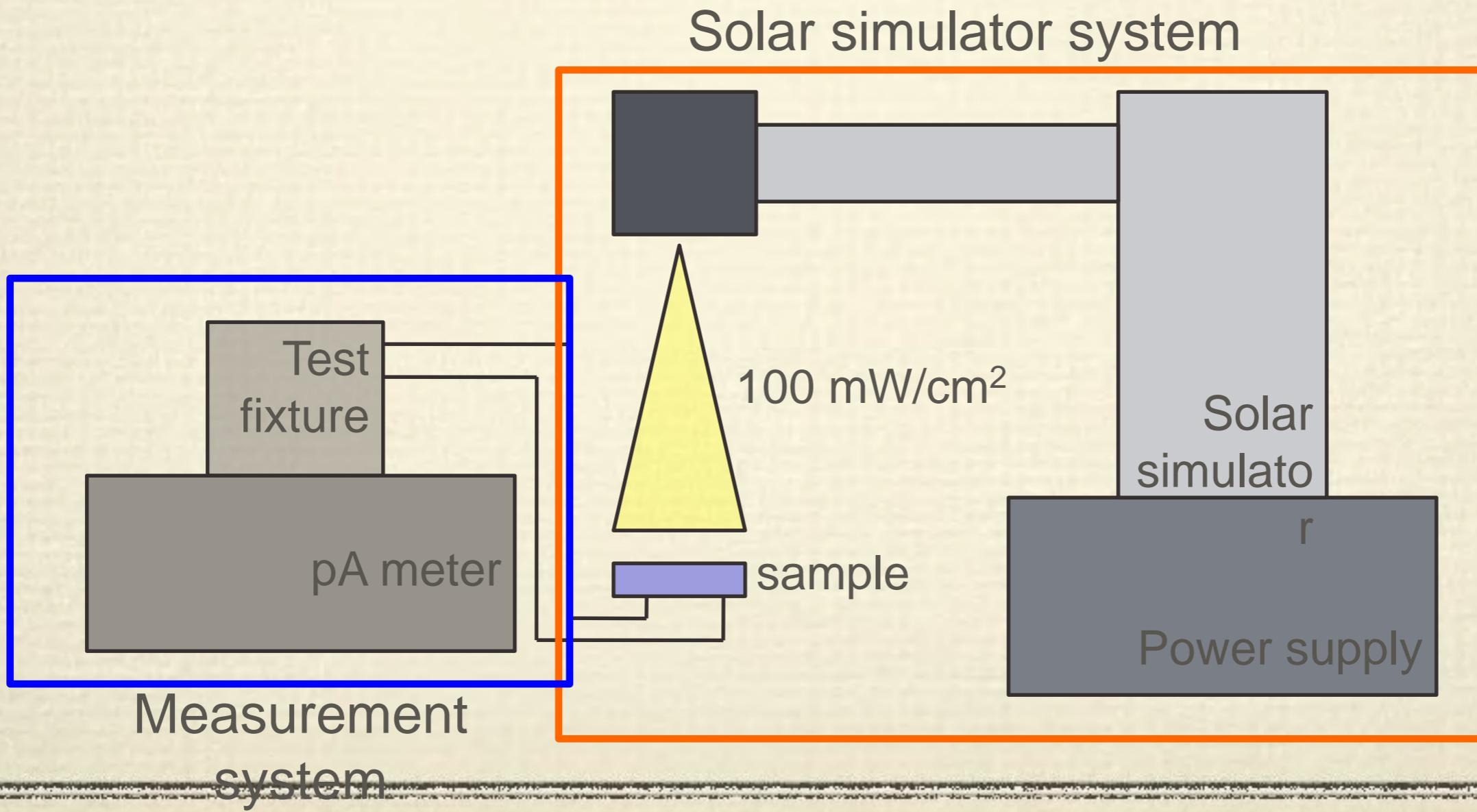


Laouthaiwattana *et al.*
(2009)



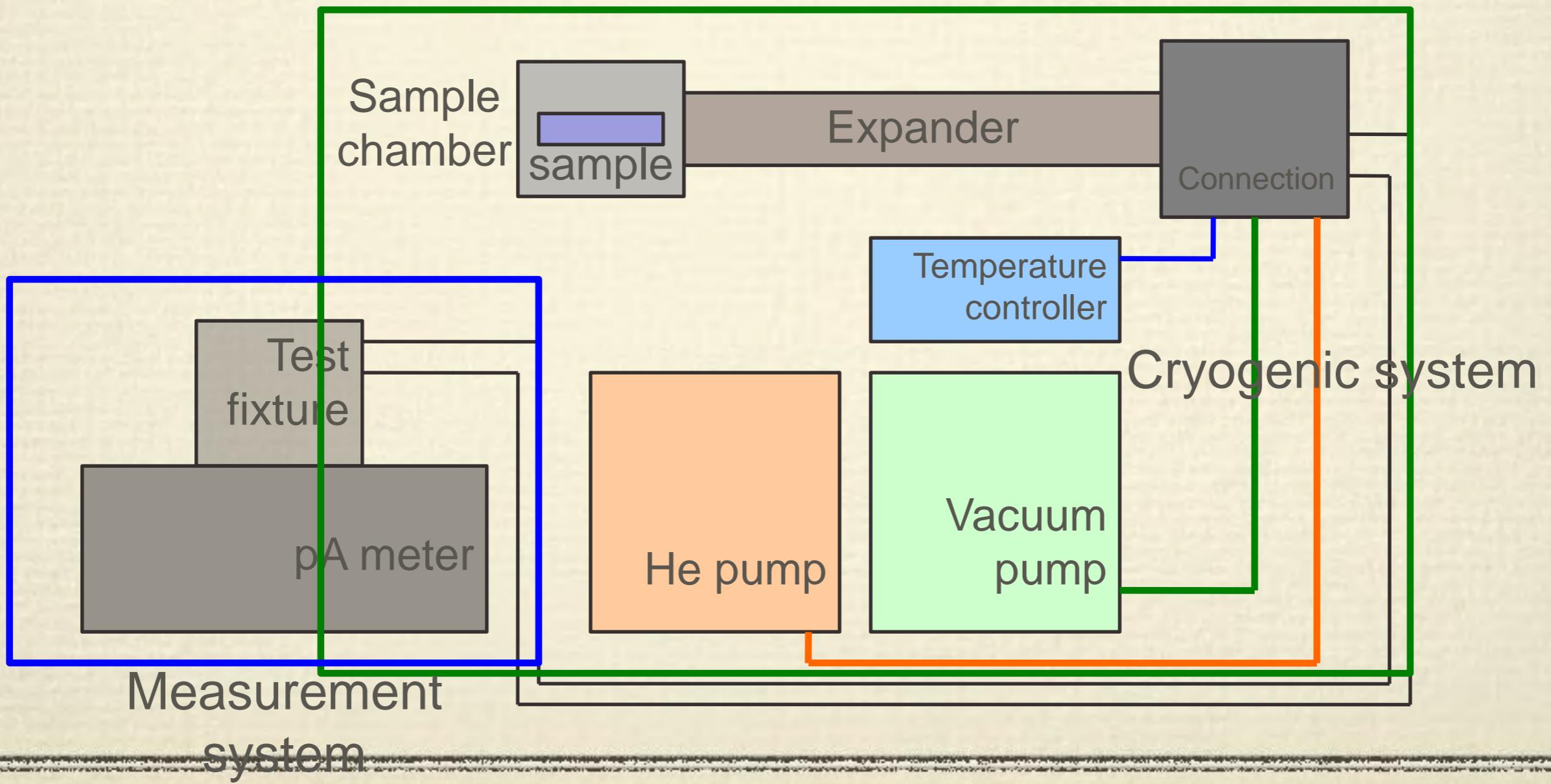
Experiments

- ❖ Effect of illumination on IV characteristics of Heterostructure InAs QDMs



Experiments

- ◆ Temperature dependency of IV characteristics of Schottky structure InAs QDMs



Results and Discussion

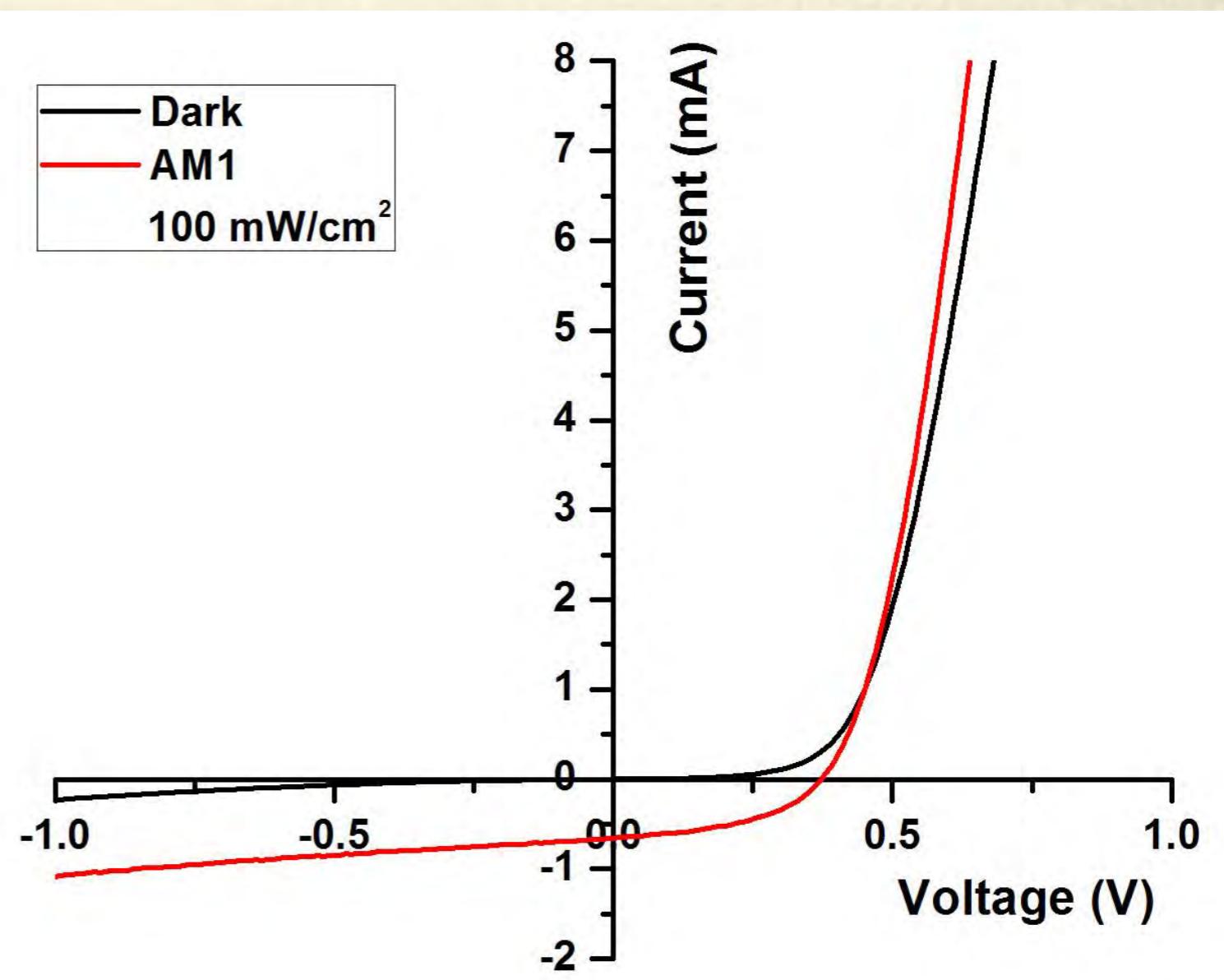
- ❖ Effect of illumination on IV characteristics of Heterostructure InAs QDMs

- ❖ 3 stacks QDMs

- ❖ $V_{oc} = 0.37 \text{ V}$

- ❖ $J_{sc} = 6.55 \text{ mA/cm}^2$

- ❖ F.F. = 0.462



Results and Discussion

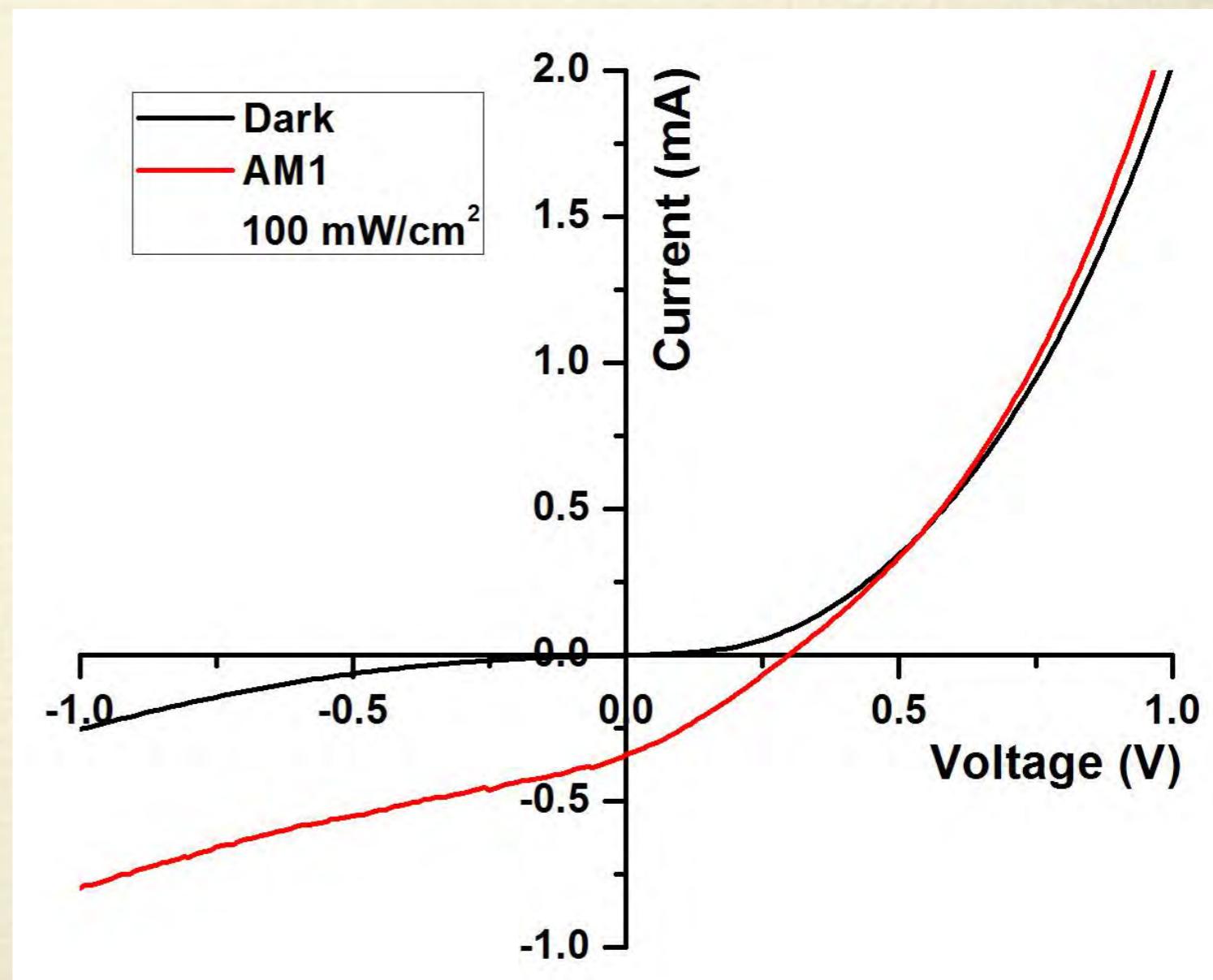
- ❖ Effect of illumination on IV characteristics of Heterostructure InAs QDMs

- ❖ 5 stacks QDMs

- ❖ $V_{oc} = 0.3$ V

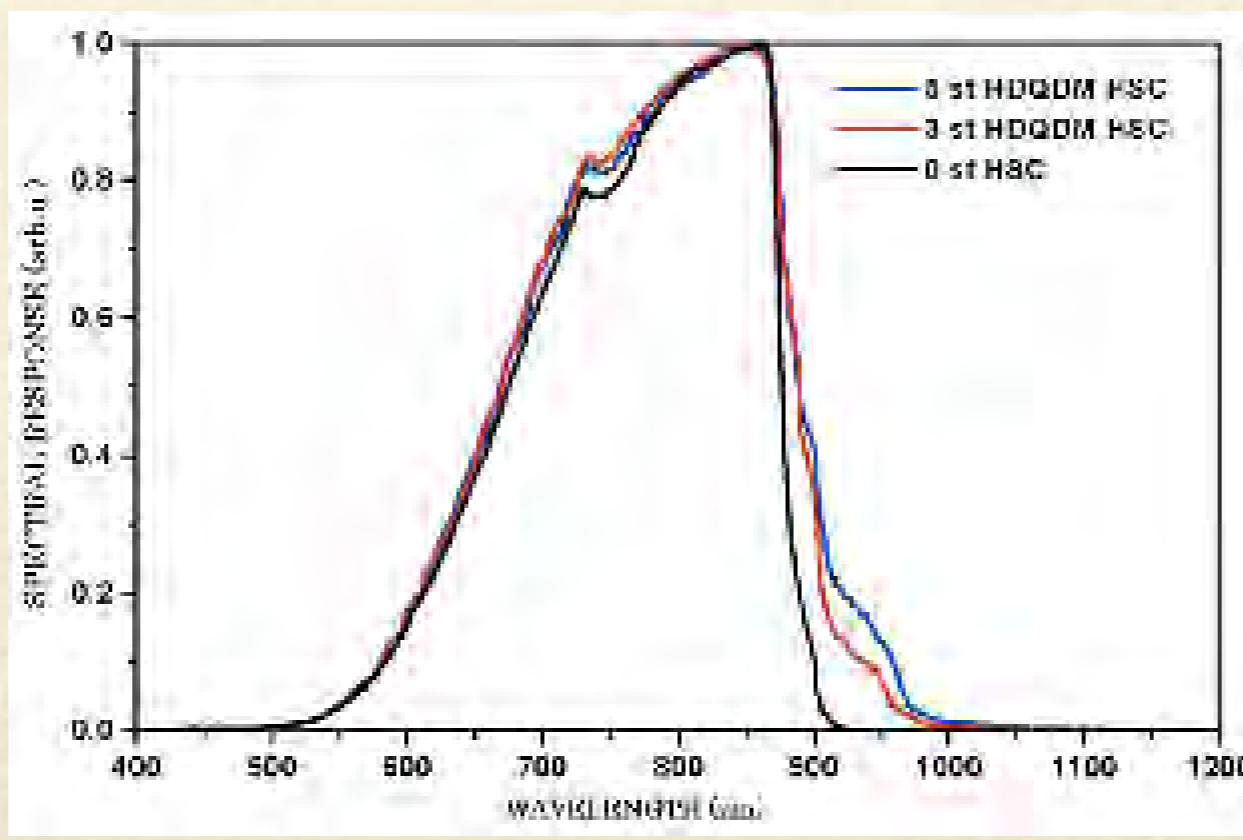
- ❖ $J_{sc} = 3.42$ mA/cm²

- ❖ F.F. = 0.289



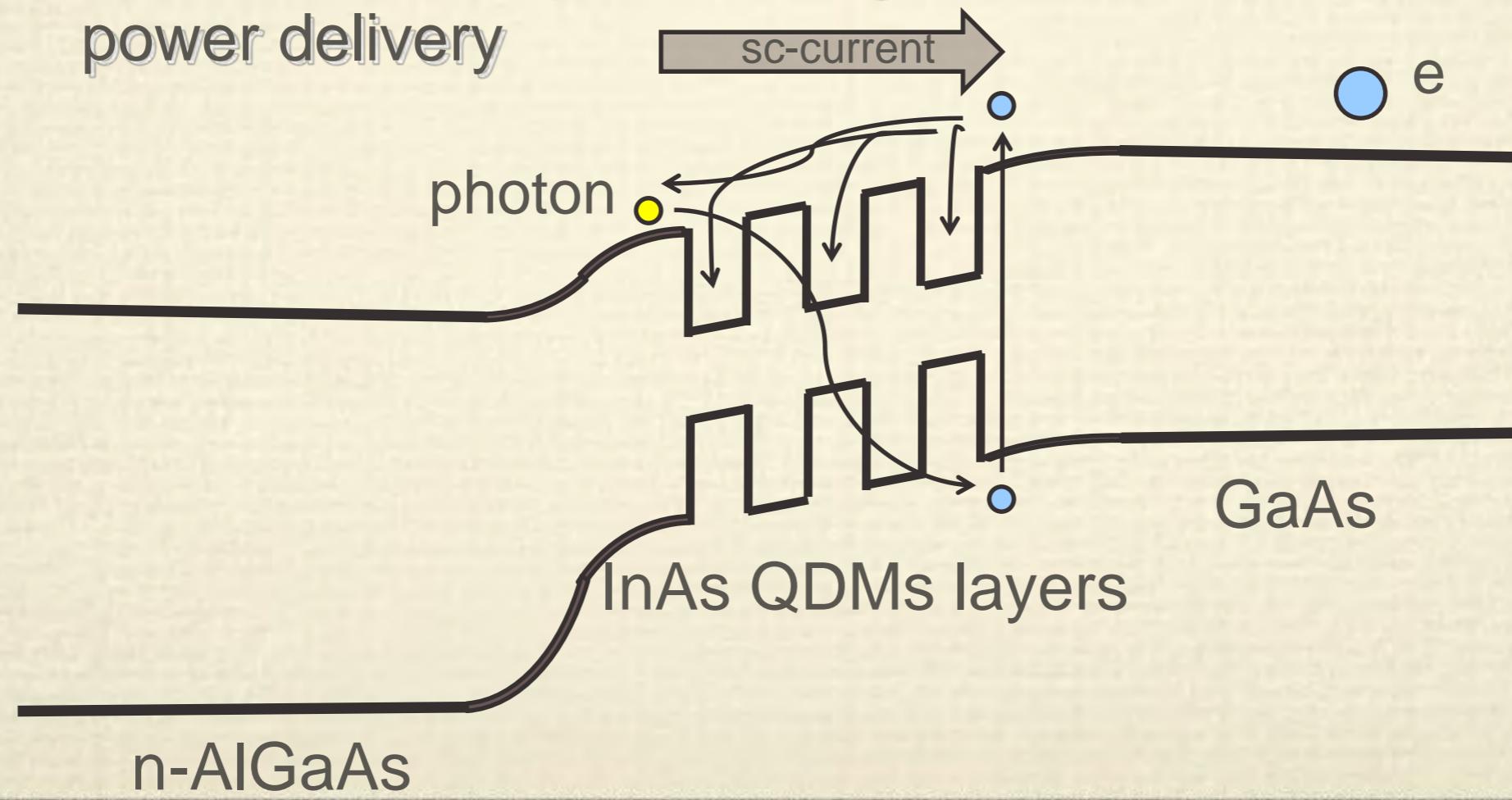
Results and Discussion

- ❖ Effect of illumination on IV characteristics of Heterostructure InAs QDMs
 - ❖ Both samples show a potential to be used as photovoltaic
 - ❖ 3 stacks QDMs provides higher V_{oc} , J_{sc} , and maximum power delivery



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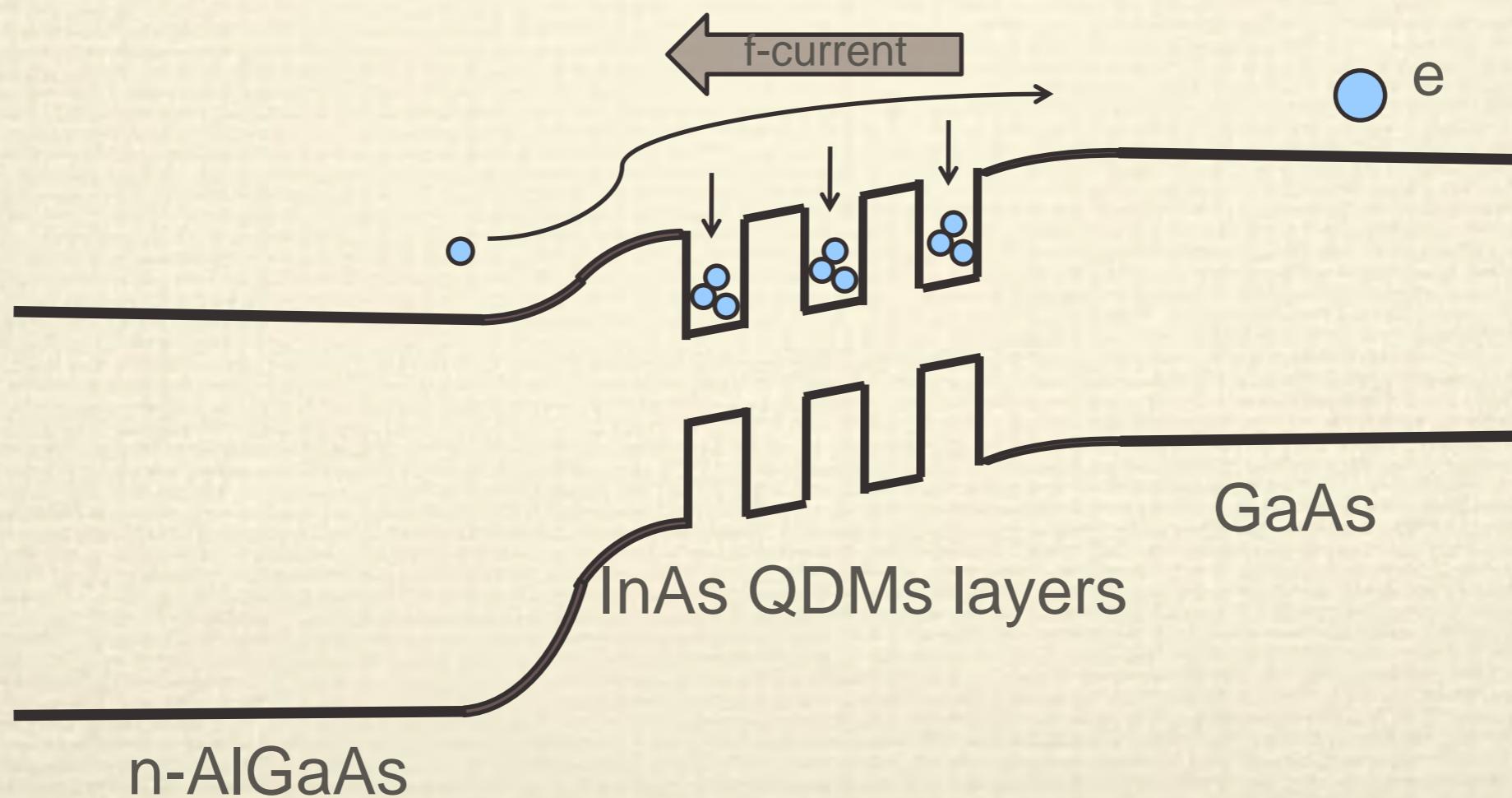


Results and Discussion

- ❖ Effect of illumination on IV characteristics of Heterostructure InAs QDMs
 - ❖ Both samples show a potential to be used as photovoltaic
 - ❖ 3 stacks QDMs provides higher V_{oc} , J_{sc} , and maximum power delivery
 - ❖ Number of stacks must be optimized

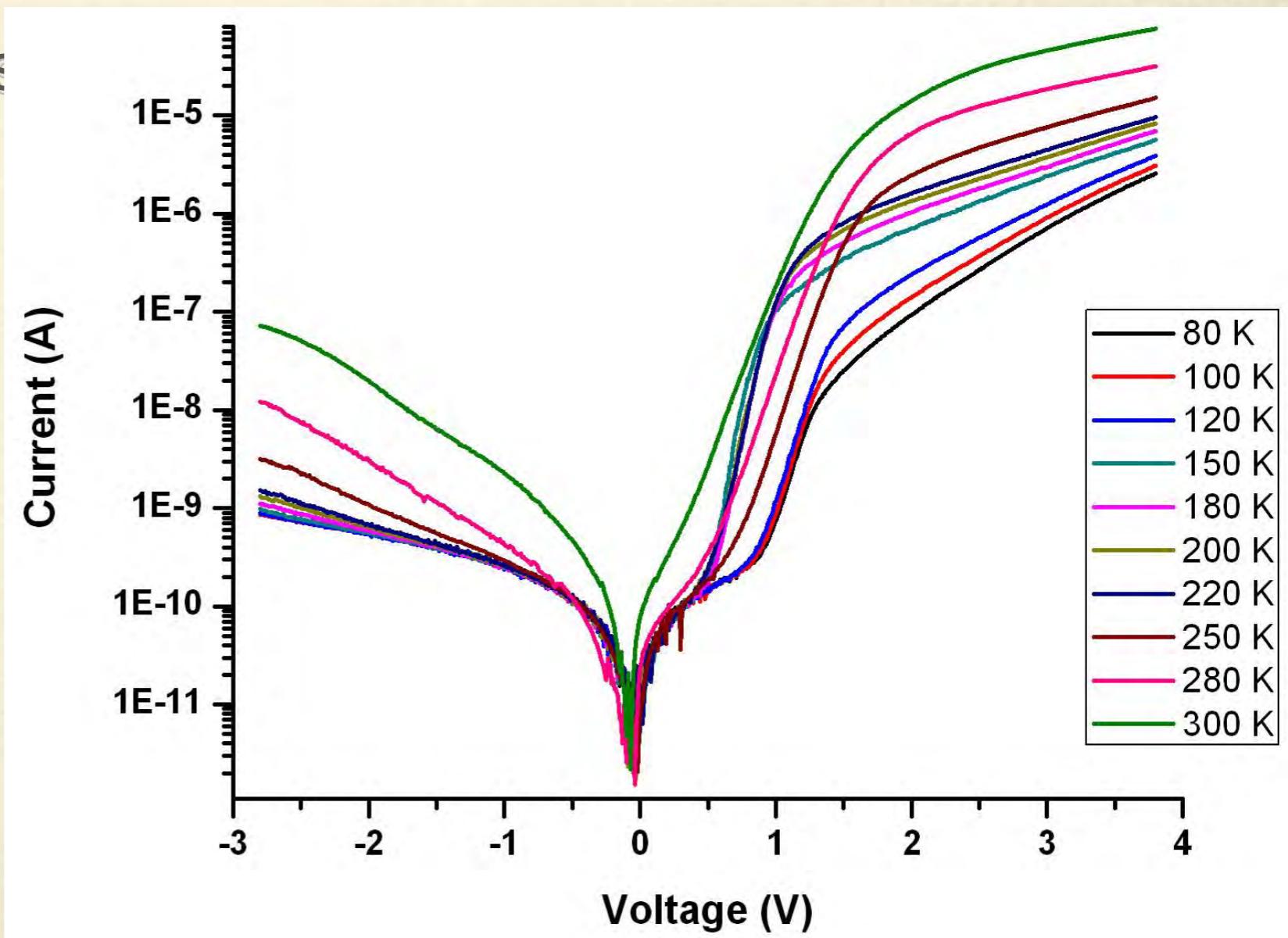
Results and Discussion

- ❖ Effect of illumination on IV characteristics of Heterostructure InAs QDMs
 - ❖ 3 stacks QDMs shows higher forward current



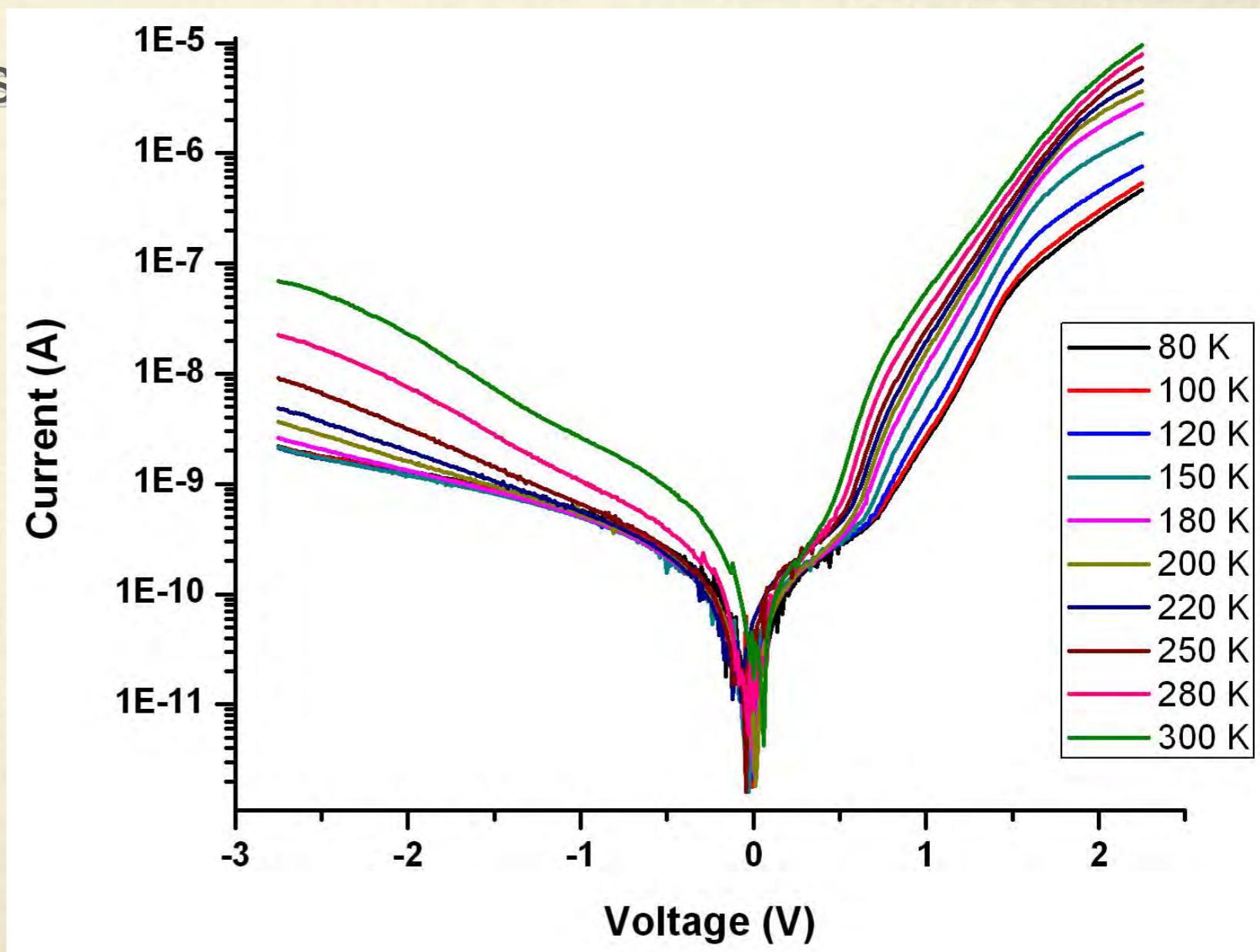
Results and Discussion

- ◆ Temperature dependency of IV characteristics of Schottky structure InAs QDMs



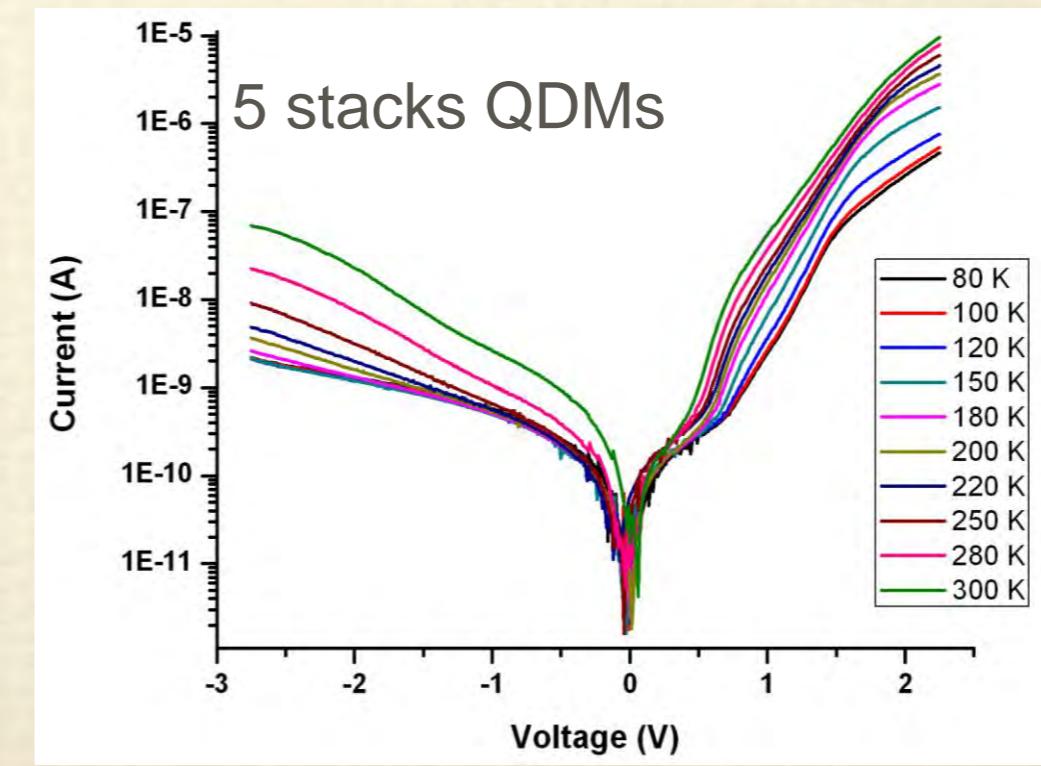
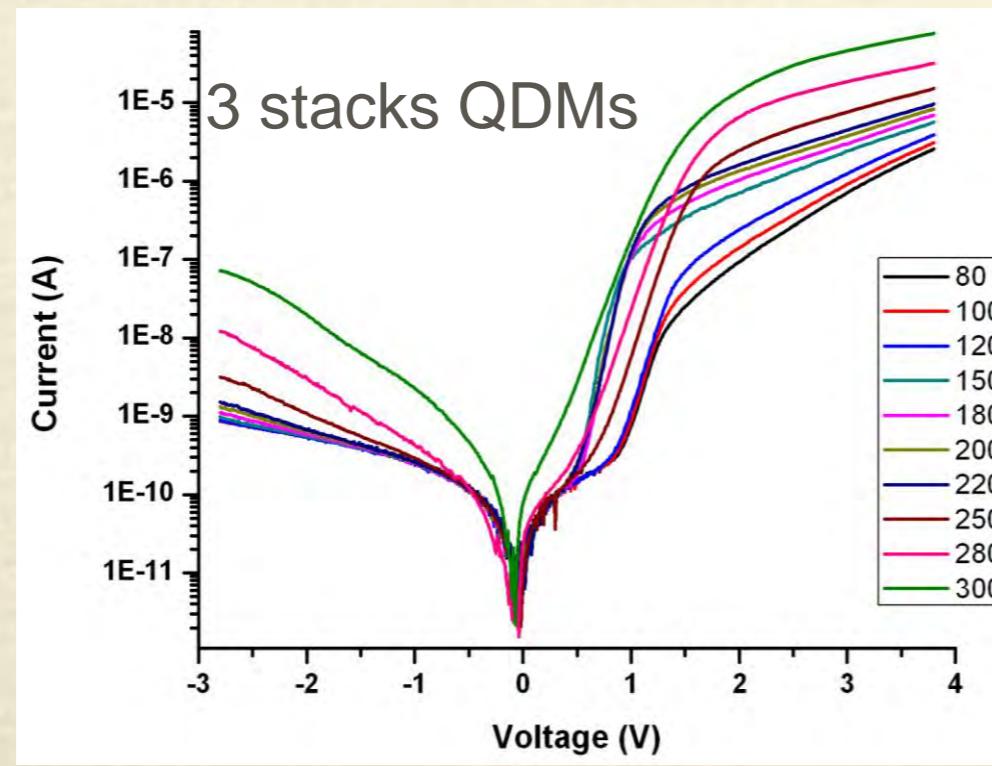
Results and Discussion

- # ◆ Temperature dependency of IV characteristics of Schottky structure InAs QDMs



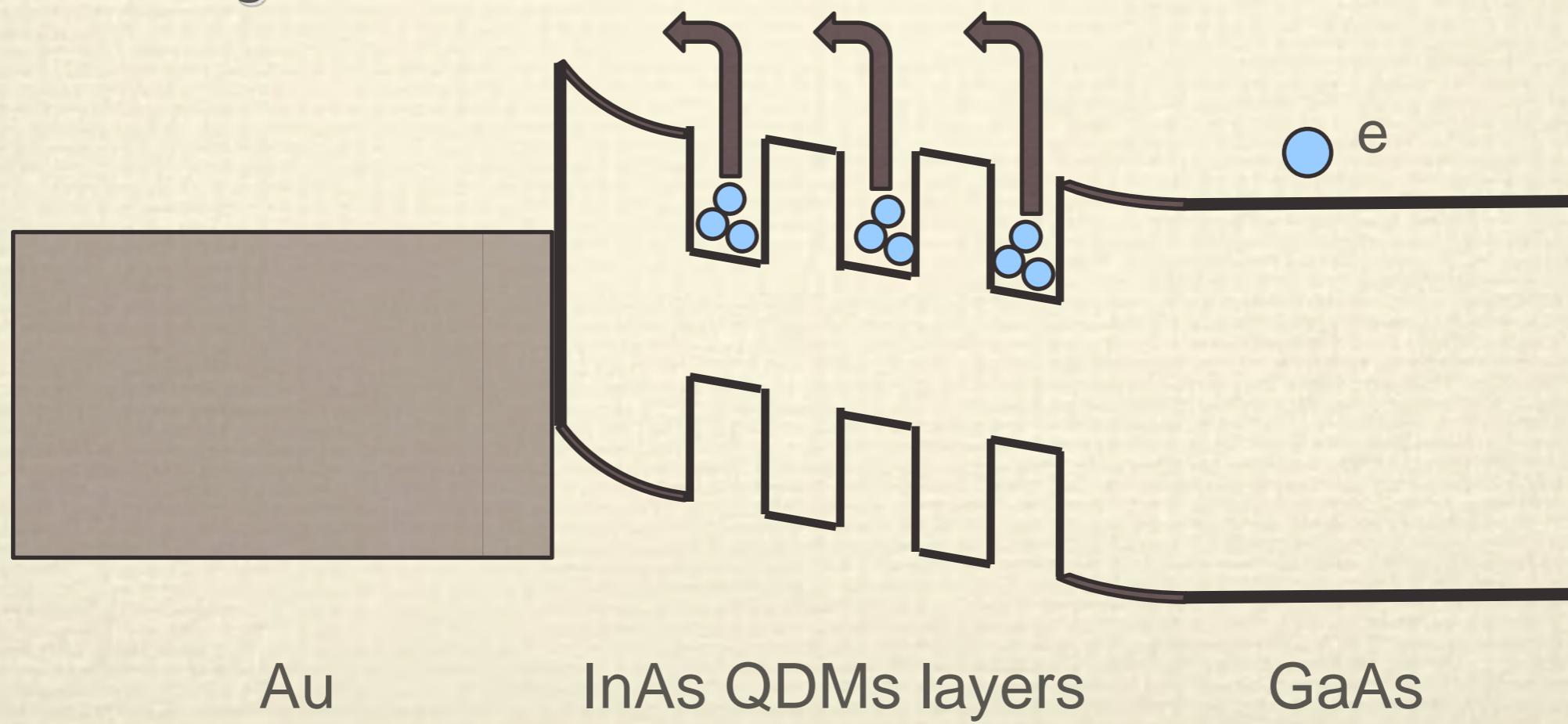
Results and Discussion

- ❖ Temperature dependency of IV characteristics of Schottky structure InAs QDMs
 - ❖ Current increases as temperature rises up
 - ❖ Multiple gradients and gradients change as temperature changes



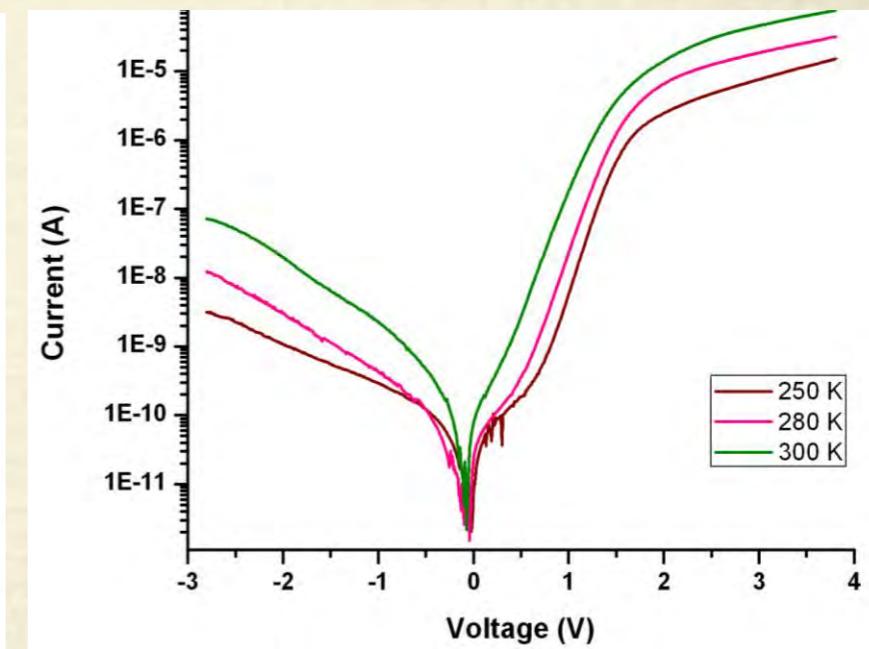
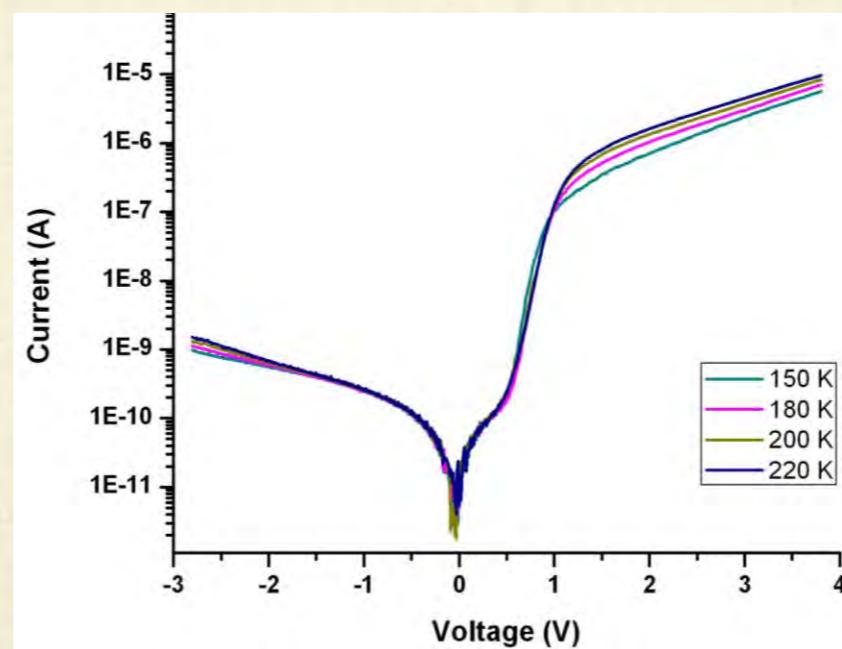
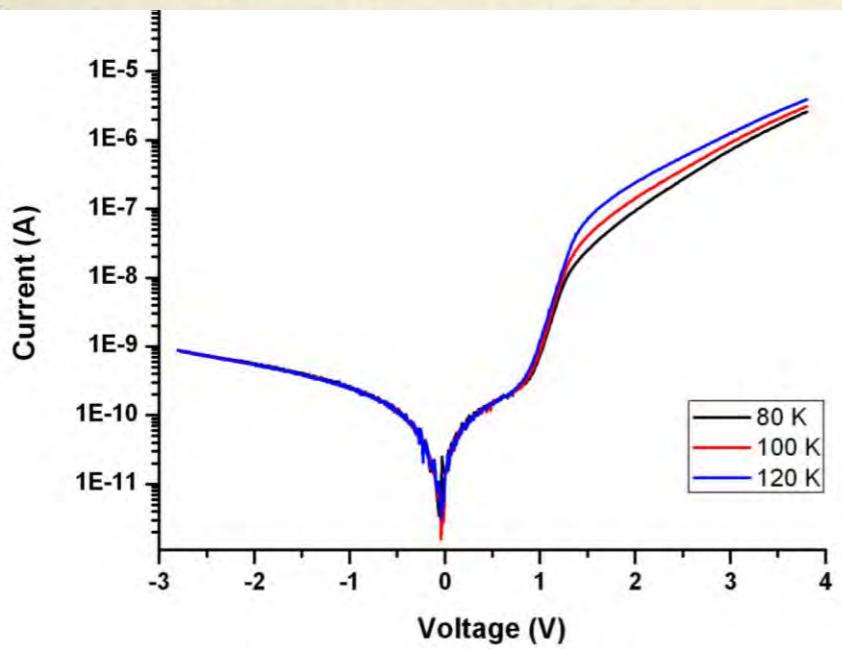
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Results and Discussion

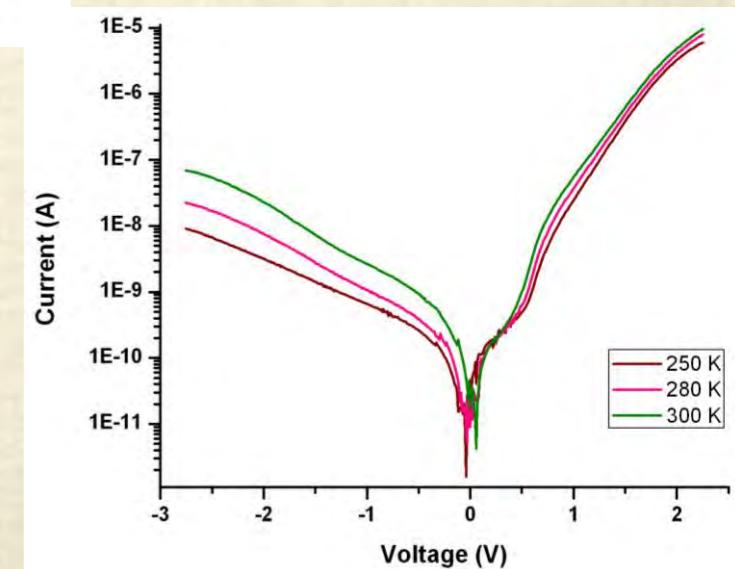
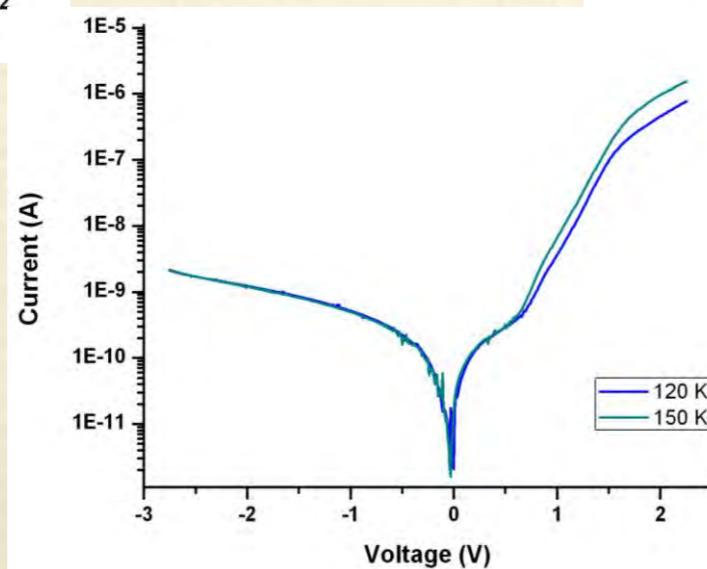
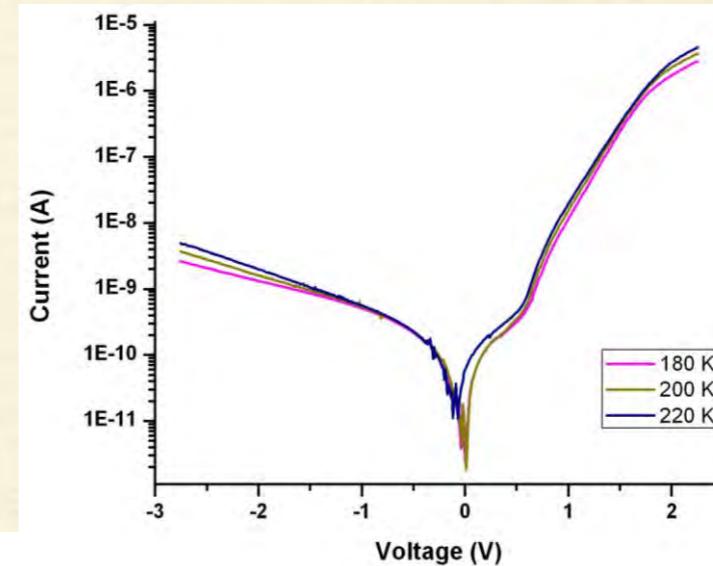
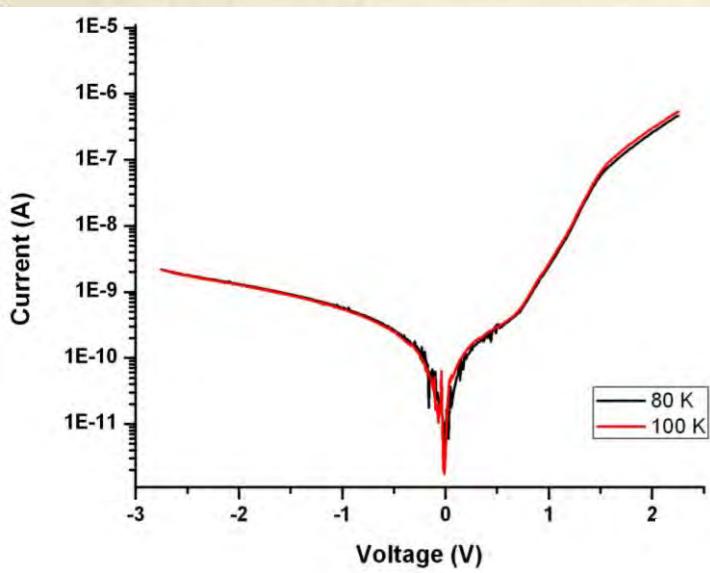
- ❖ Temperature dependency of IV characteristics of Schottky structure InAs QDMs
 - ❖ 3 stacks QDMs : 3 IV groups



Results and Discussion

- ❖ Temperature dependency of IV characteristics of Schottky structure InAs QDMs

- ❖ 5 stacks QDMs :



Conclusion

- ❖ Heterostructure InAs QDMs have generated V_{oc} and J_{sc} under illumination
 - ❖ The structures can be developed for photovoltaic application
 - ❖ The number of QDMs stacks must be optimized for better efficiency
- ❖ Schottky structure InAs QDMs show IV temperature dependent property
 - ❖ Carriers in QDMs layer surpass the barrier height at different temperature → multiple gradients
 - ❖ Raw data for further research and development of QDs based devices

Thank you

Q&A