

Selective Growth of CdTe on Patterned CdS Substrates for High Efficiency CdTe Solar Cells

Brandon Aguirre^a; Rafael Ordonez^a; Carlos Sanchez^b; Maria Salazar^b, Edward Gonzales^c; Bruce Burkel^b; Farhana Anwar^a; Gregory Nielson^b; David Zubia^a; Jose Luis Cruz-Campa^b

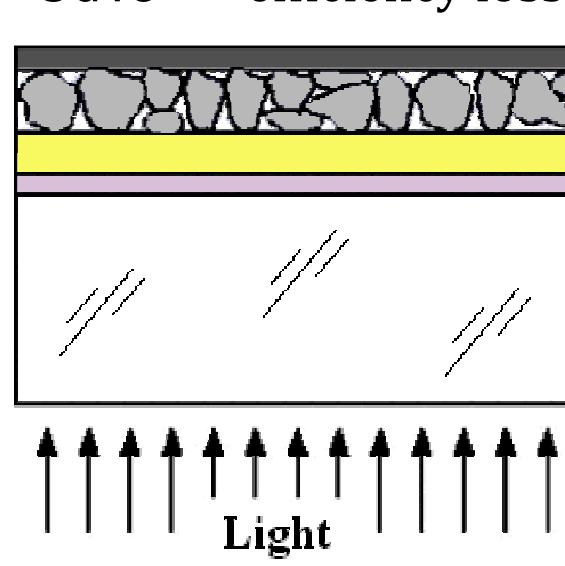
^aThe University of Texas at El Paso, El Paso TX 79968, ^bSandia National Laboratories, Albuquerque NM 87185, ^cThe Center for Integrated Nanotechnologies, Albuquerque NM 87185

Abstract

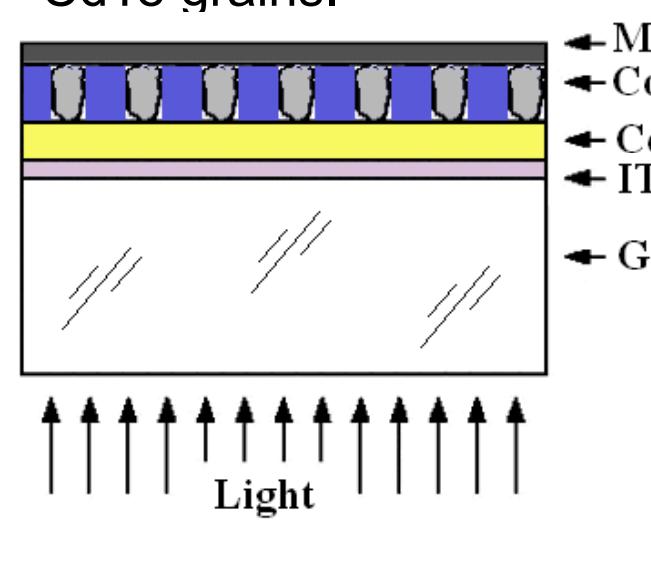
Laboratory CdTe solar cell performance has remained stagnant for the last 17 years at 16% and due to low module efficiency, the cost of photovoltaic (PV) power is still 2 to 4 times the cost of power from the grid. The overall objective of this project is pseudomorphic growth of ZnCdTe on CdS with nanotemplated growth windows to dramatically reduce defects in the nano-crystals and increase the efficiency of CdS/CdTe modules. In this work, selective growth of CdTe and ZnTe was achieved on micro and nano-templates. Structural characterization showed single CdTe and ZnTe grains per nano-window and electrical characterization showed the feasibility of using CdTe selective growth to fabricate solar cell devices.

Introduction

Non-Uniform growth on polycrystalline CdTe → efficiency losses.



Improve uniformity by isolating CdTe grains.

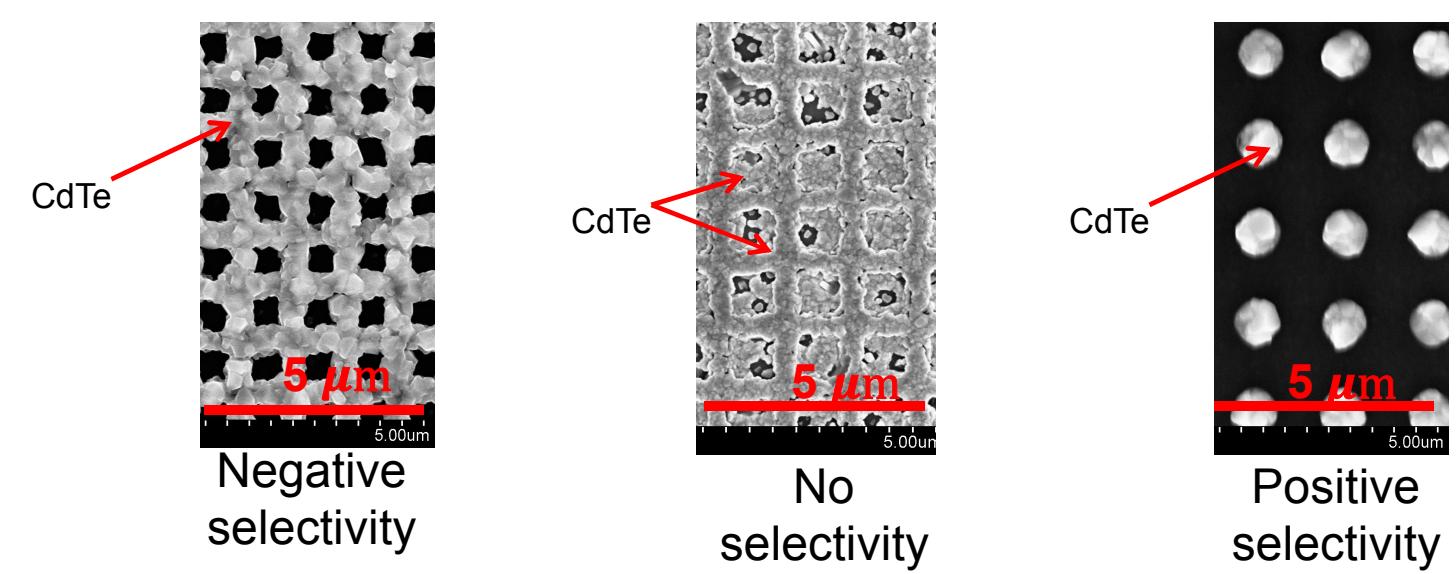


Objectives

- Selective growth of ZnTe and CdTe on patterned Si & CdS substrates
- Analysis of micro and nano ZnTe/CdTe islands
- Solar cell device fabrication/characterization using patterned CdS substrates

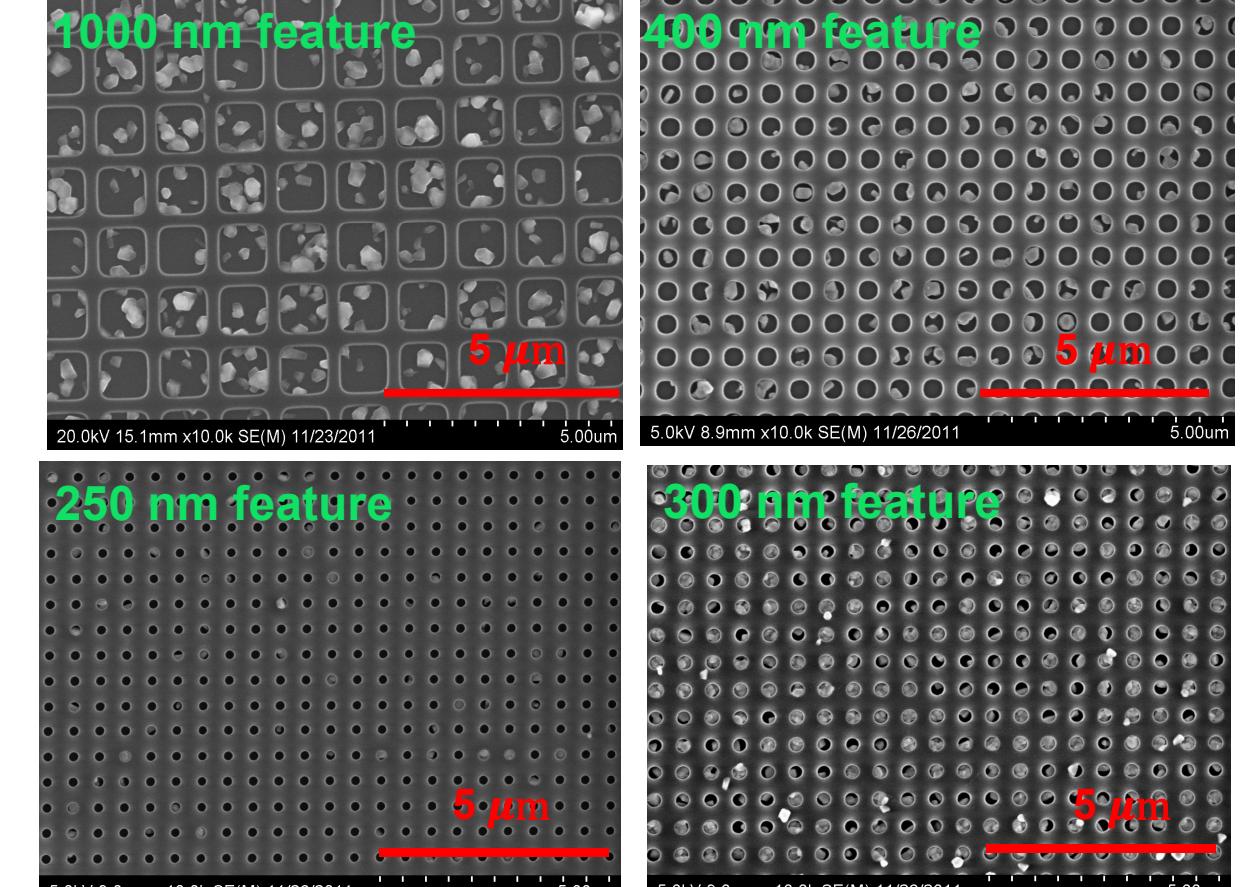
Types of Selectivity

Deposition conditions (T_{source} , T_{sub} , time) were used to achieve negative, no and positive CdTe selectivity.

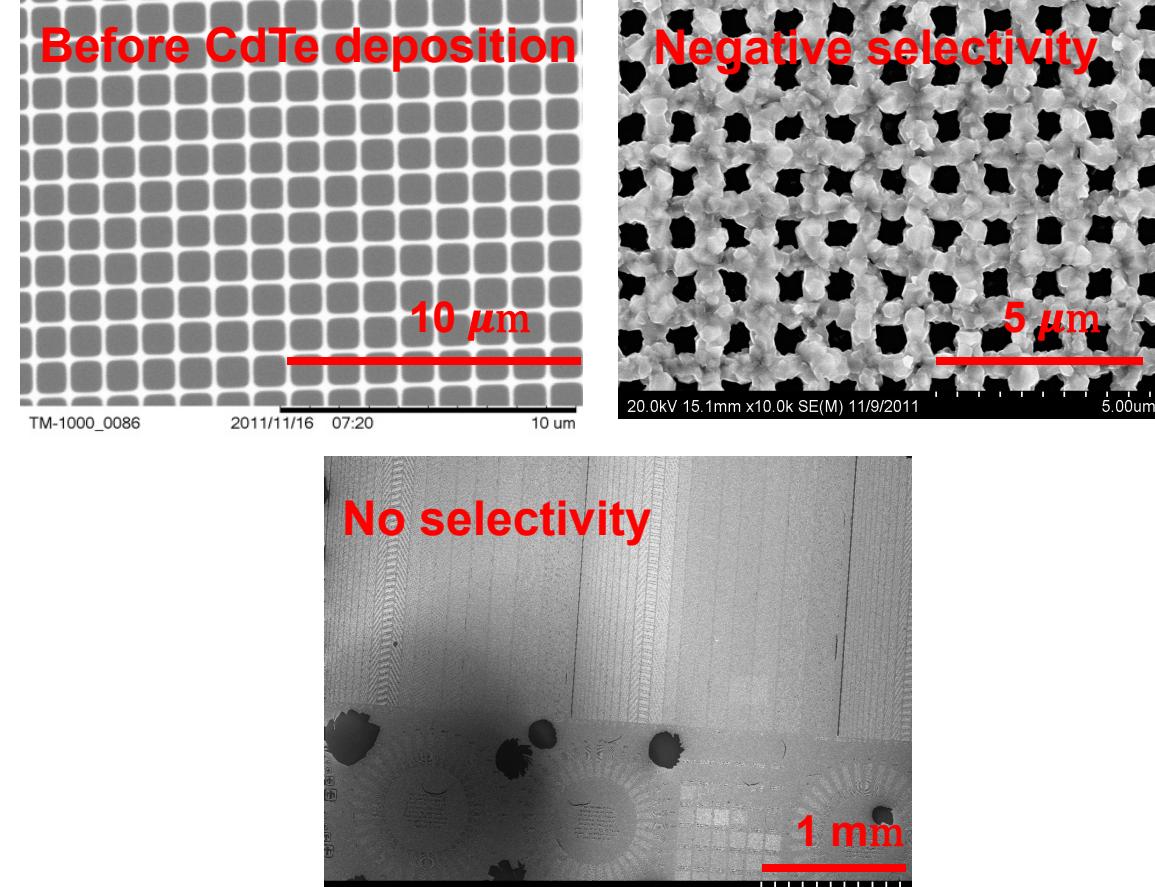


Non-active devices

ZnTe selective growth on Si patterned substrates was achieved for different window sizes.

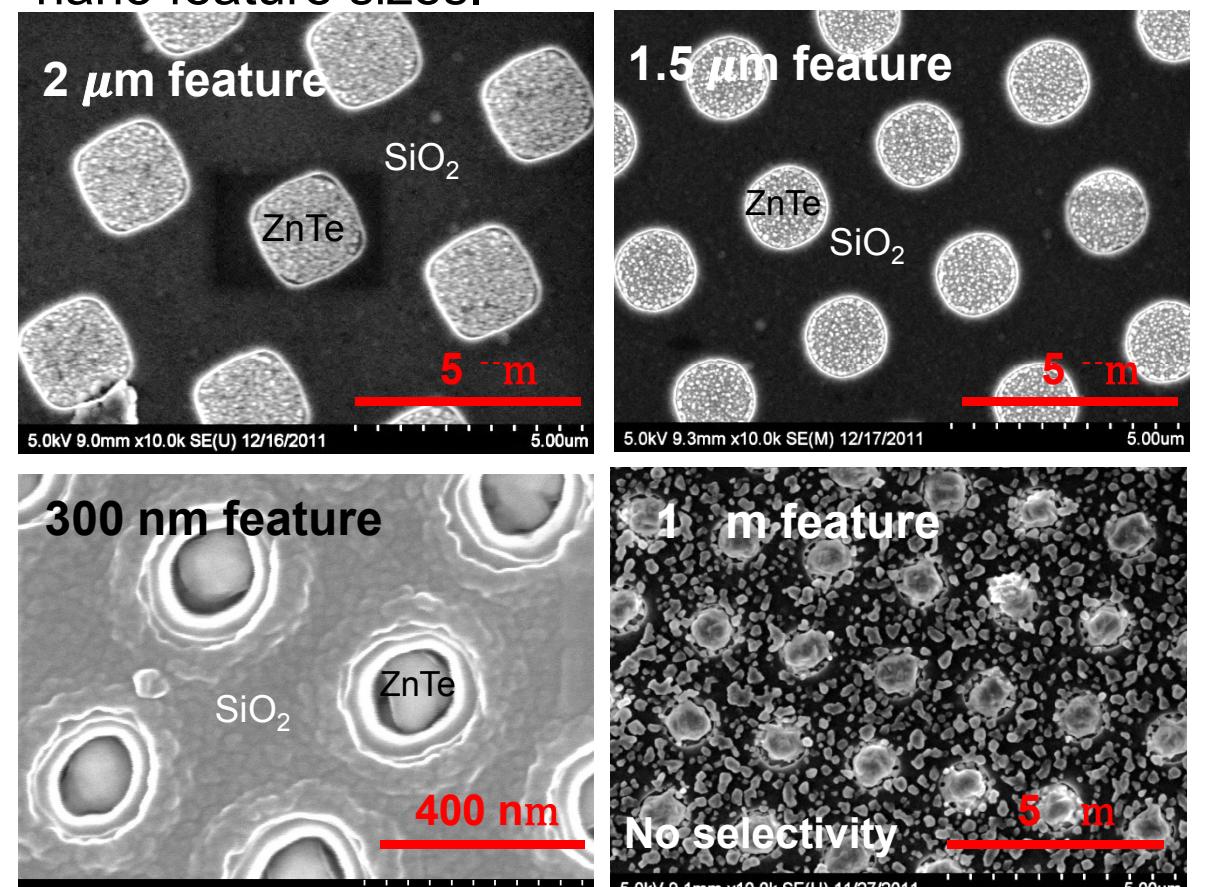


CdTe selective growth on Si patterned substrates showed negative and no selectivity.

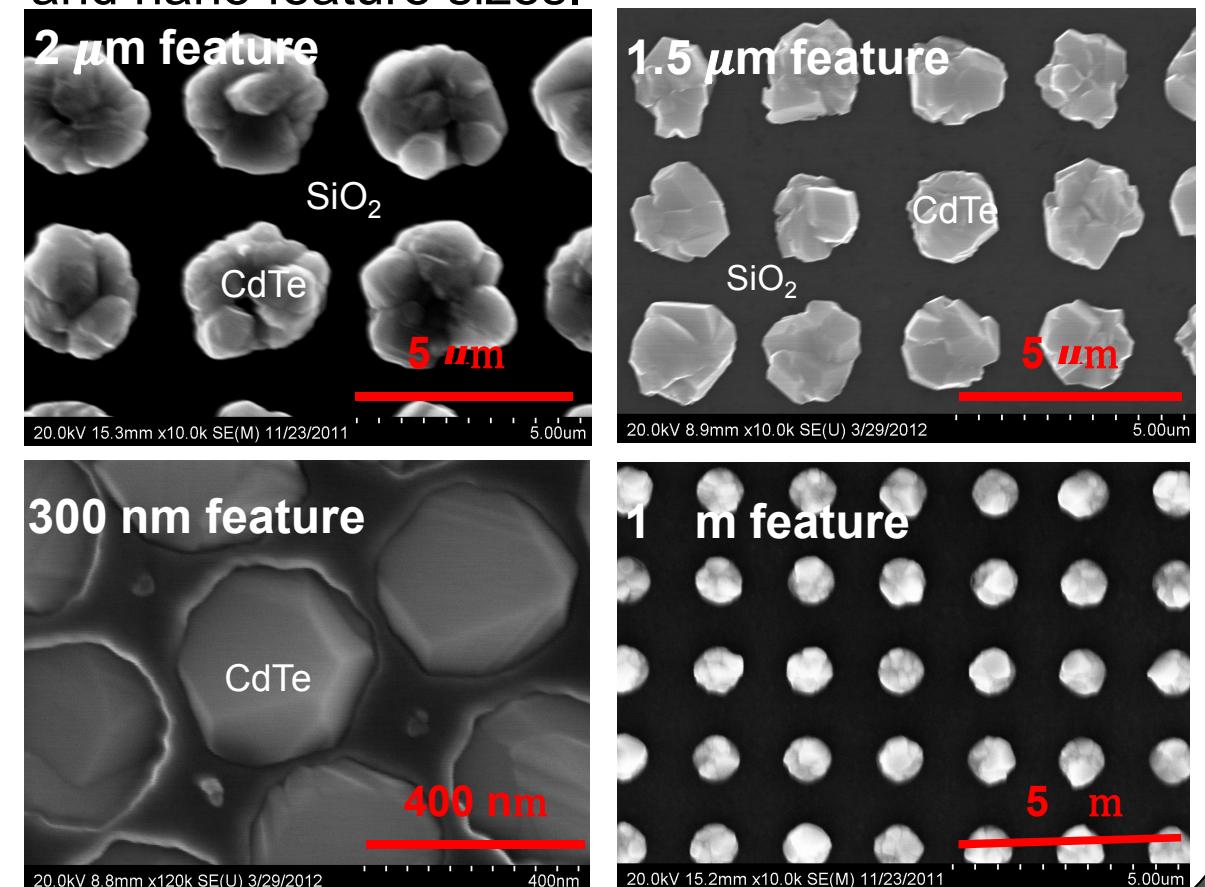


Active devices

Positive and no ZnTe selective growth on CdS patterned substrates was achieved for micro and nano feature sizes.

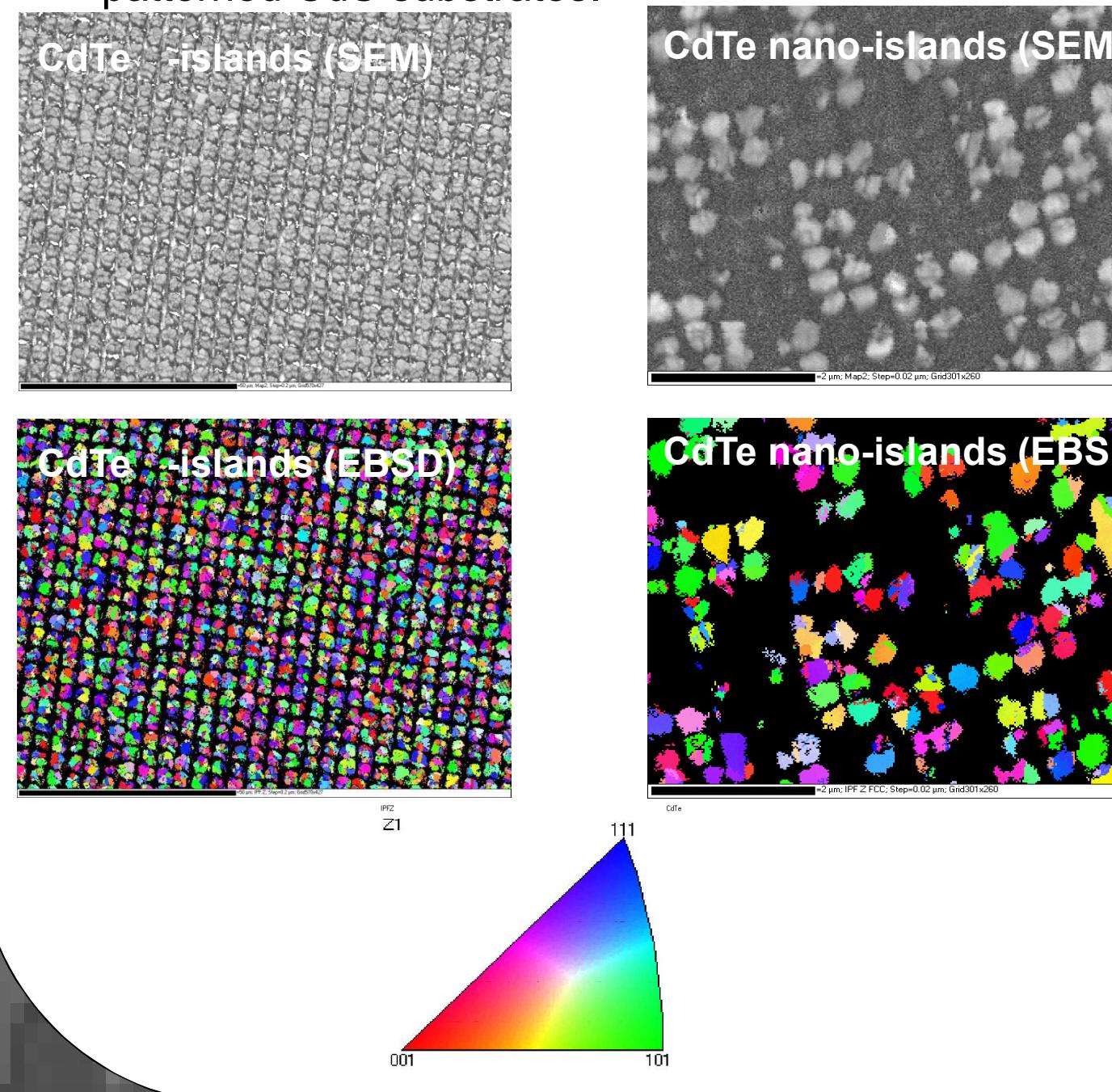


Positive CdTe selective growth on CdS patterned substrates was achieved for micro and nano feature sizes.

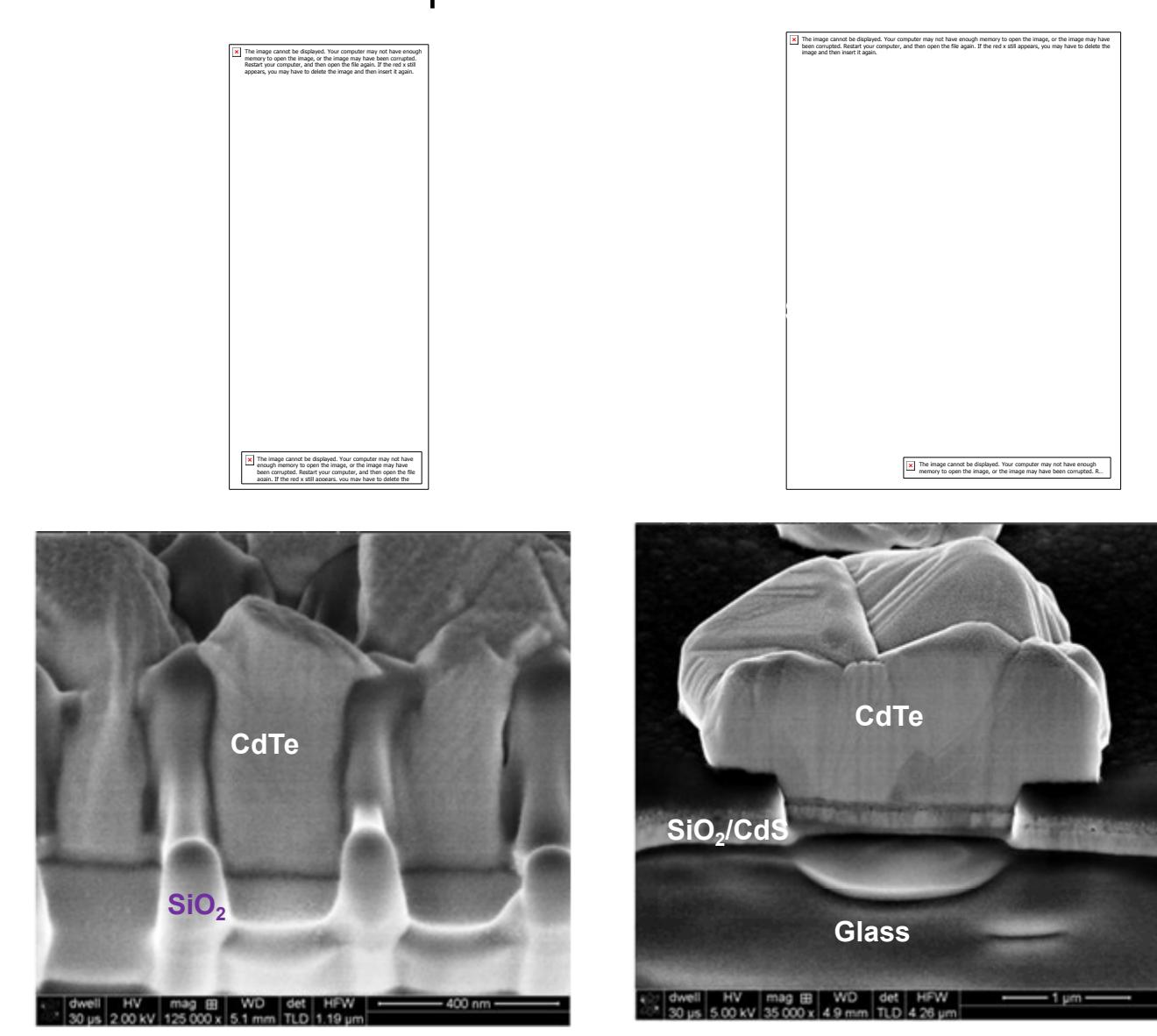


CdTe selective growth grain characterization

EBSD analysis performed on μ - and nano CdTe selective growth confirms multi-grain structures with many orientations on μ -patterned CdS and single-grain structures with single orientations on nano-patterned CdS substrates.

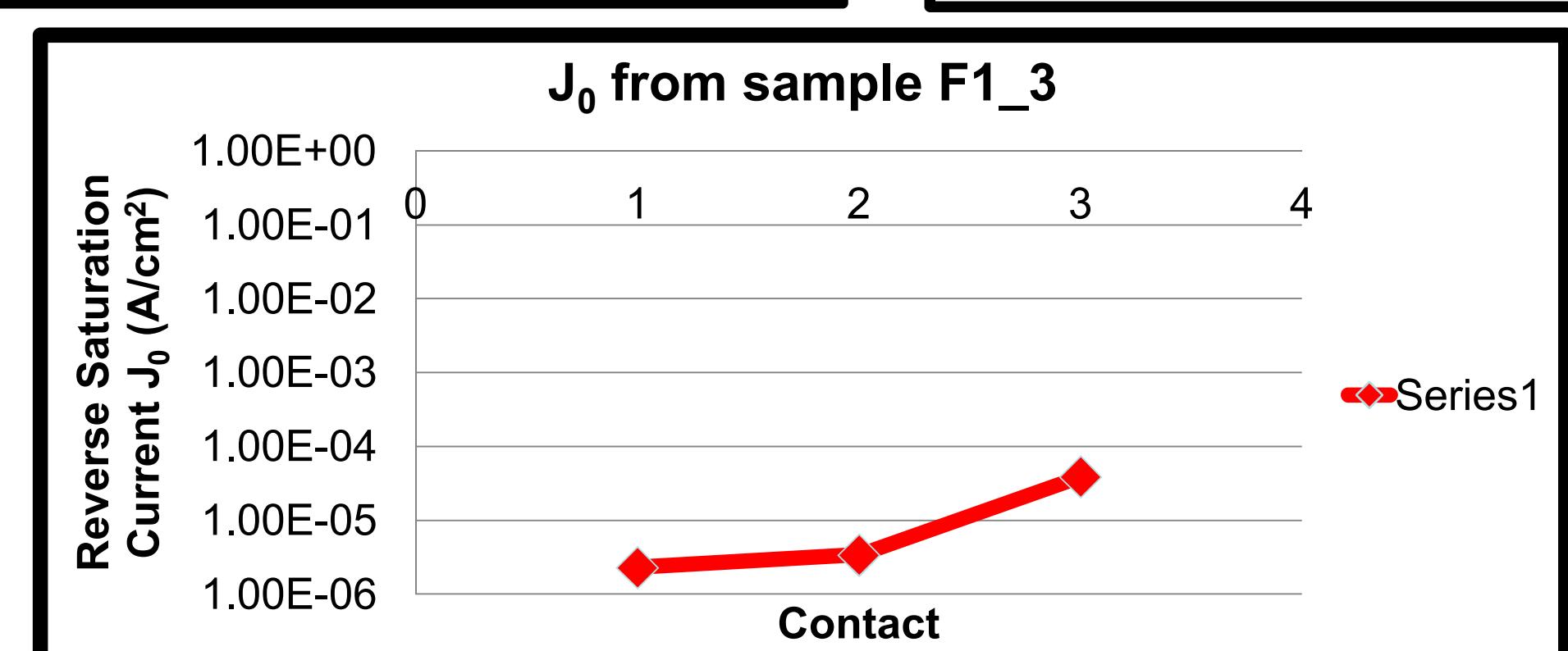
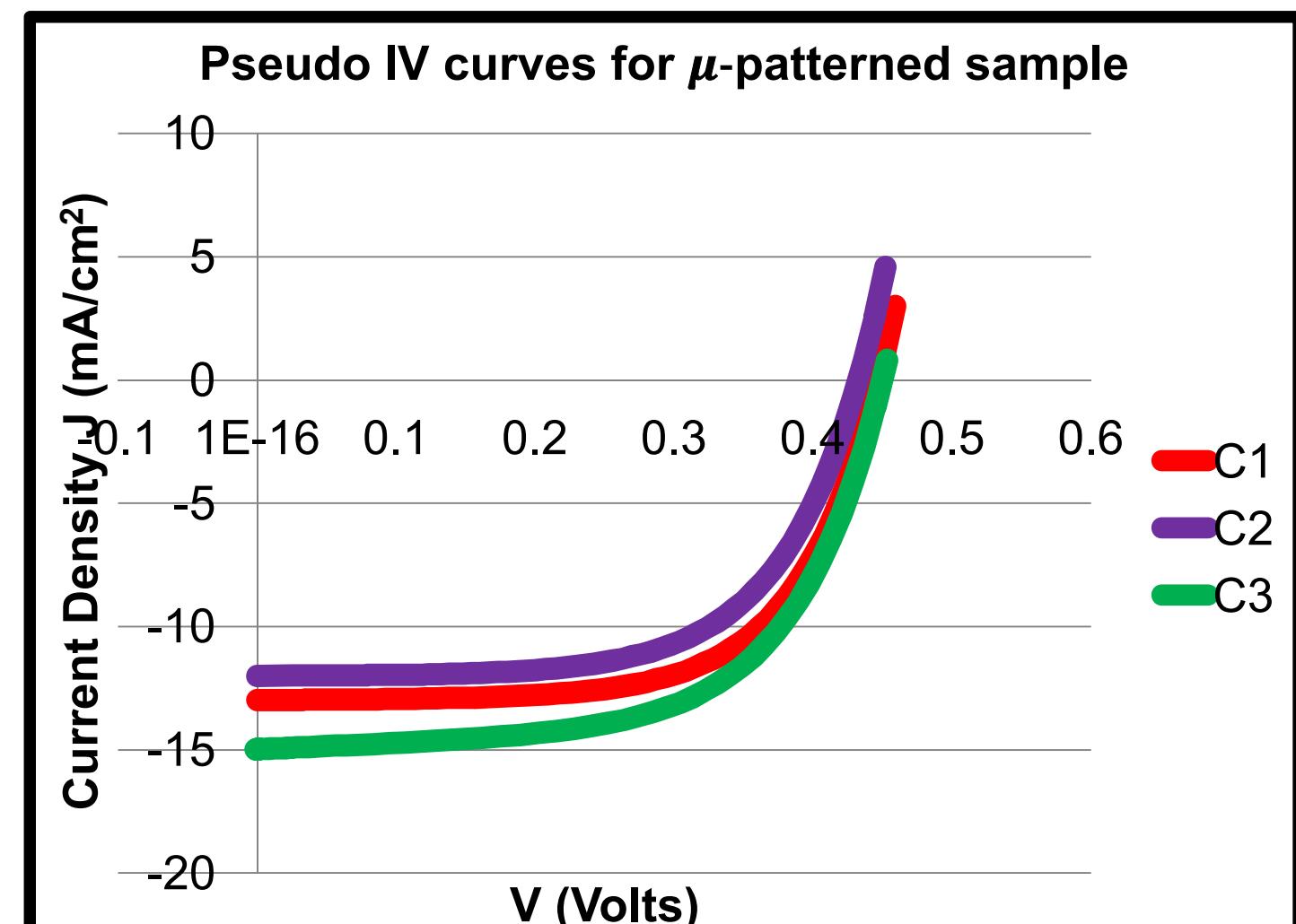
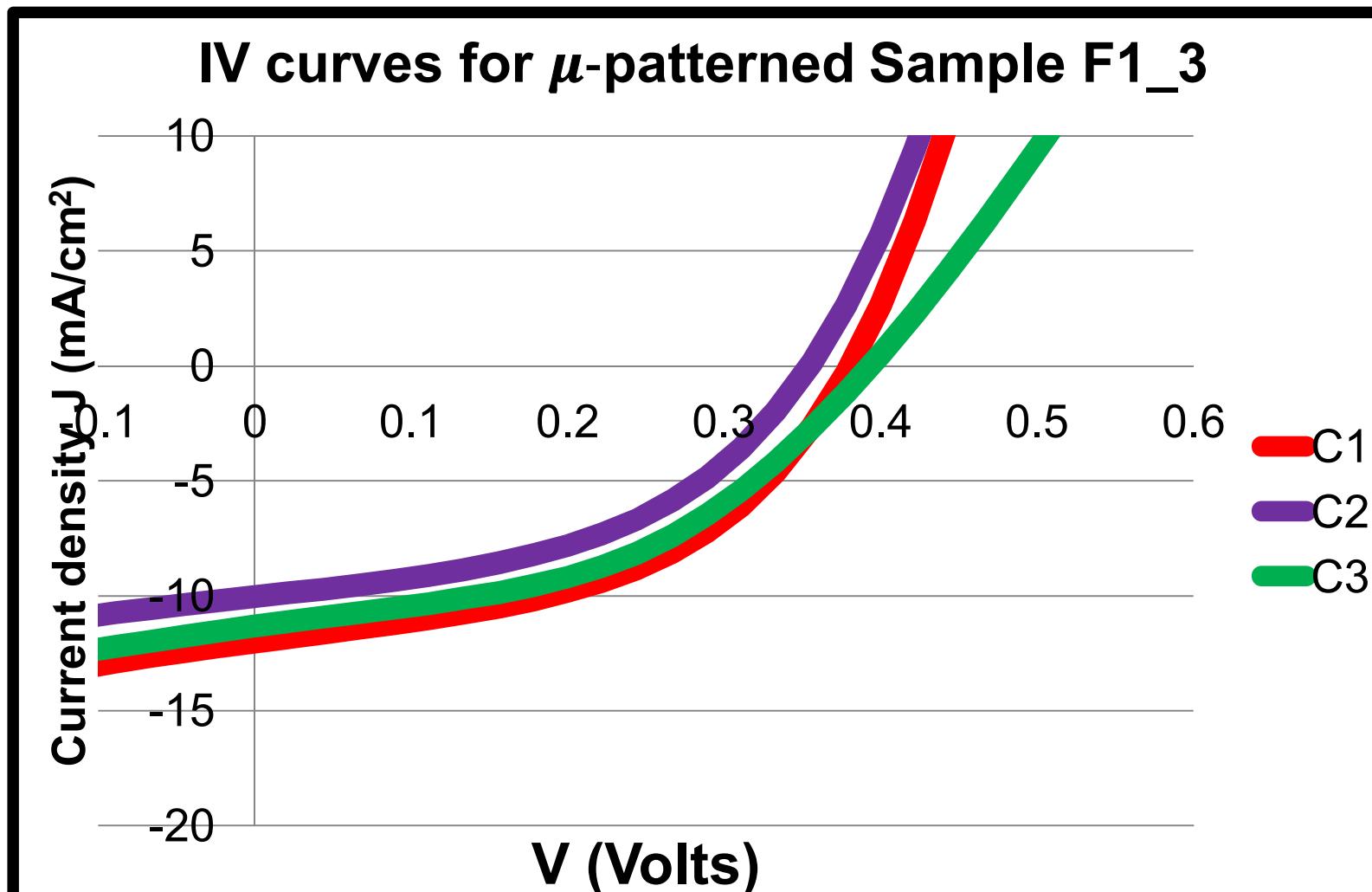


FIB/SEM cross-section analysis performed on micro and nano single xtal and polycrystalline CdS substrates confirms multi-grain CdTe structures on micro-patterned substrates vs single-grain CdTe structures on nano-patterned substrates.



Preliminary Device characterization with μ -patterned CdS substrates

IV and Suns Voc measurements show that solar cell devices can be fabricated with micro-patterned CdS substrates. Reverse saturation current (J_0) will be used as an indirect measurement of defects in CdTe/CdS interface.



Conclusions

- ✓ ZnTe and CdTe selective growth on micro and nano-patterned CdS substrates
- ✓ Reduction in number of grains from micro to nano-patterned structures
- ✓ Single and uniform crystal achieved at the nano scale
- ✓ Demonstration of operational device with micro-patterned CdS substrates

References

[1] Jose L. Cruz-Campa, David Zubia, Xiaowang Zhou, Donald Ward, Carlos A. Sanchez, Jose J. Chavez, Brandon A. Aguirre, Farhana Anwar, Damian Marrufo, Ping Lu, Michael J. Rye, John C. McClure, and Gregory N. Nelson, Nanopatterning And Bandgap Grading To Reduce Defects In CdTe Solar Cells, Proc. 38th IEEE PVSC, In Press (2012).
 [2] J. Terrazas, A. Rodriguez, C. Lopez, A. Escobedo, F. Kuhlmann, J. McClure, D. Zubia, Ordered polycrystalline thin films for high performance CdTe/CdS solar cells. *Thin Solid Films* 2005; 490:148.