微纳光电子材料与器件工艺原理

Emerging Technologies

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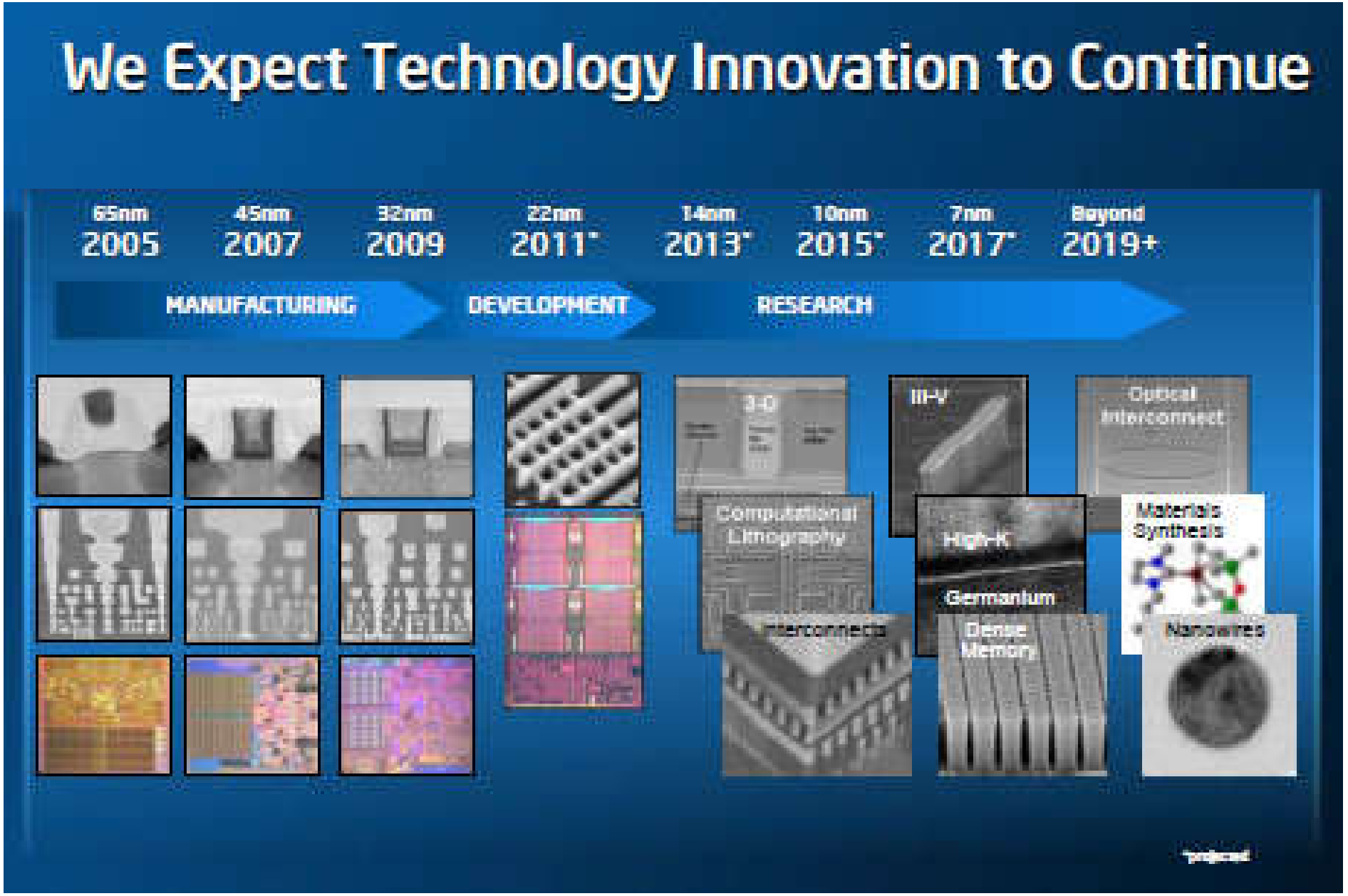
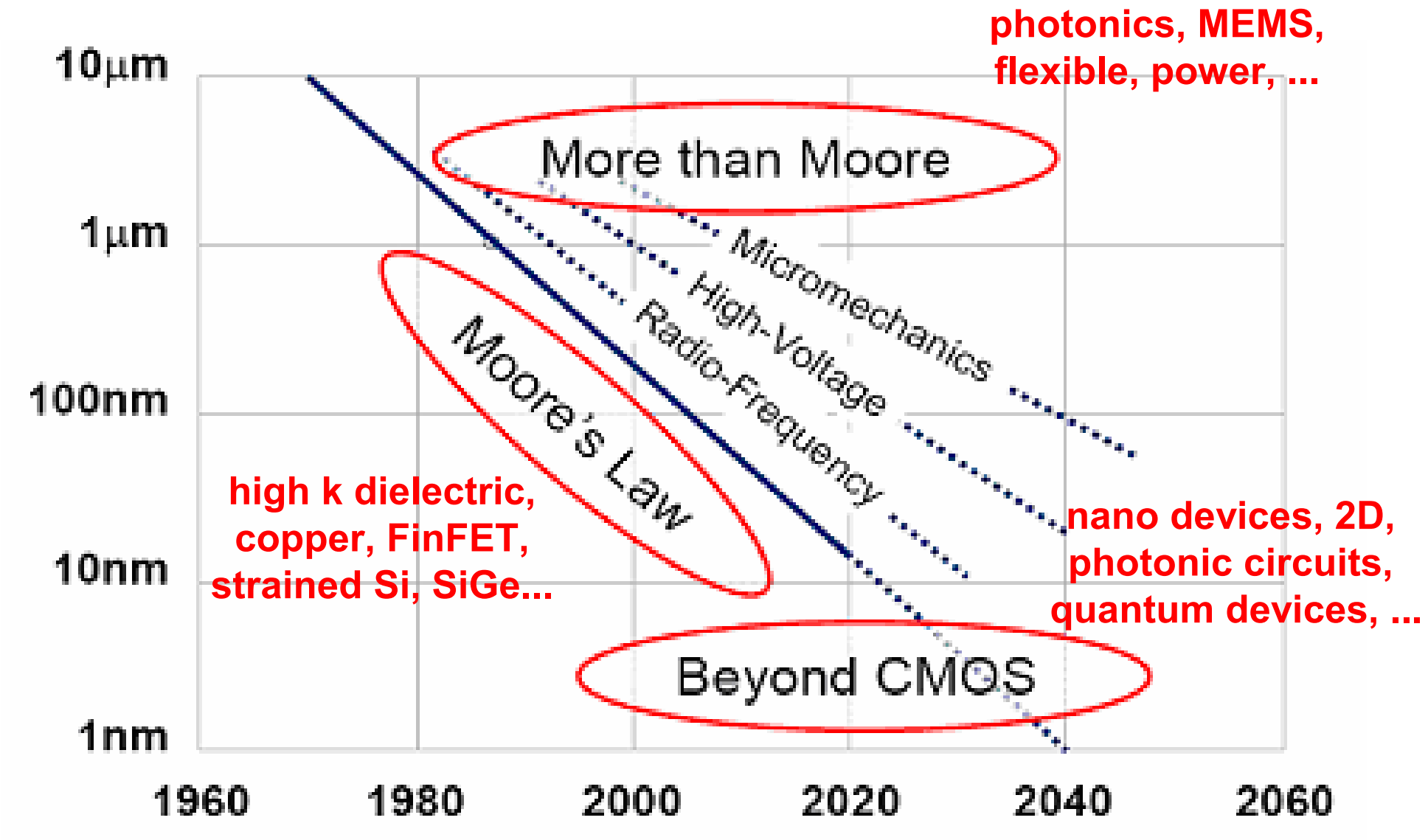
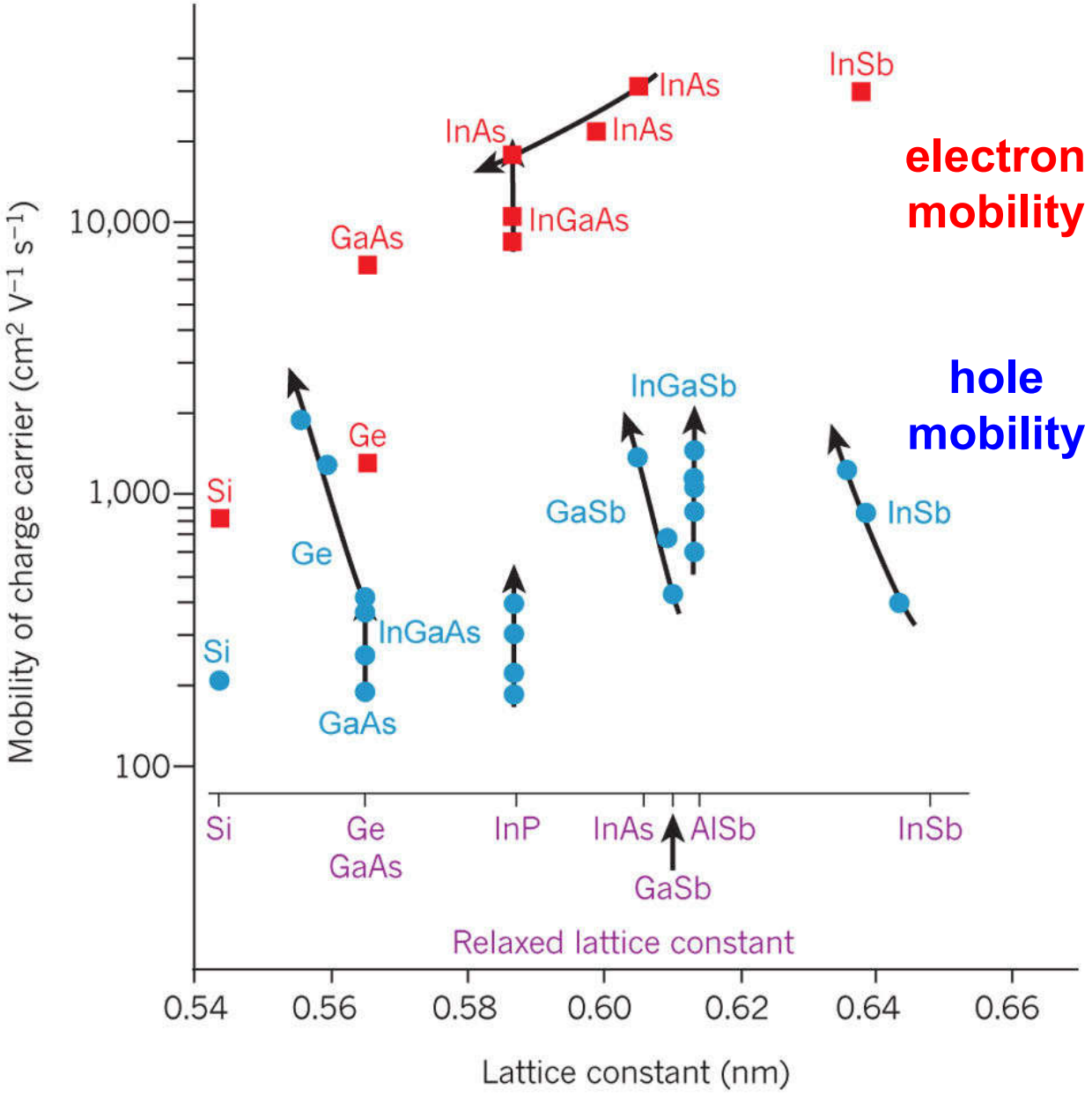
New Opportunities



New Opportunities



High Electron Mobility Transistor (HEMT)

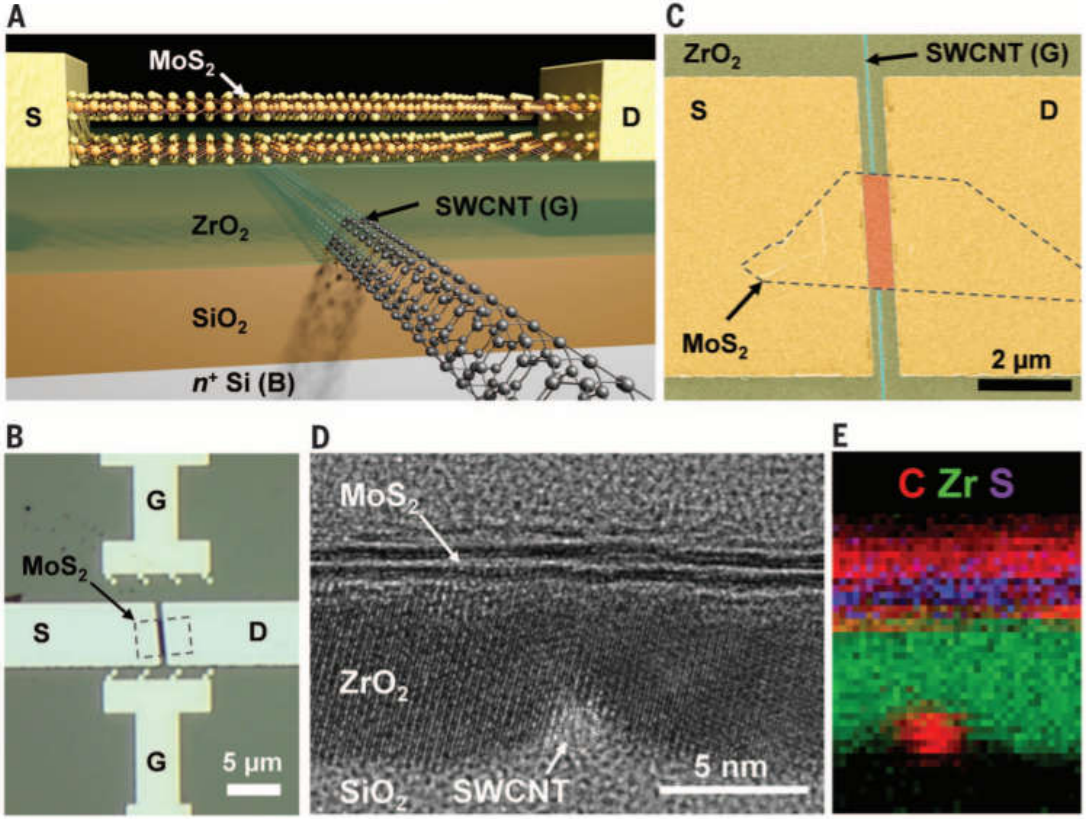


Nano-Transistors

DEVICE TECHNOLOGY

MoS_2 transistors with 1-nanometer gate lengths

Sujay B. Desai,[1,2,3] Surabhi R. Madhvapathy,[1,2] Angada B. Sachid,[1,2] Juan Pablo Llinas,[1,2] Qingxiao Wang,[4] Geun Ho Ahn,[1,2] Gregory Pitner,[5] Moon J. Kim,[4] Jeffrey Bokor,[1,2] Chenming Hu,[1] H.-S. Philip Wong,[5] Ali Javey[1,2,3]*

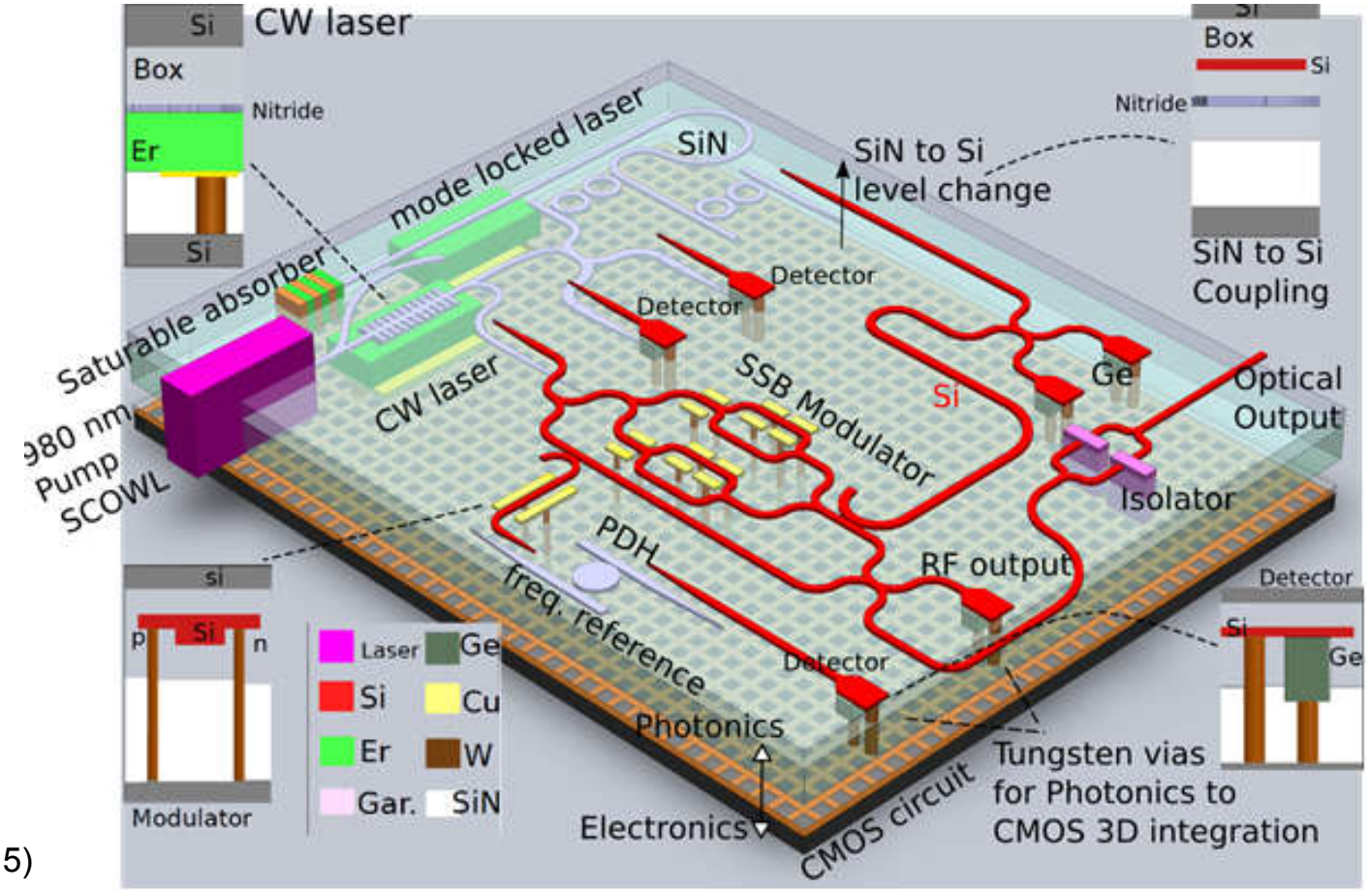


S. Desai, *et al.*, *Science* **354,** 99 (2016)

Photonic Integrated Circuits

Single-chip microprocessor that communicates directly using light

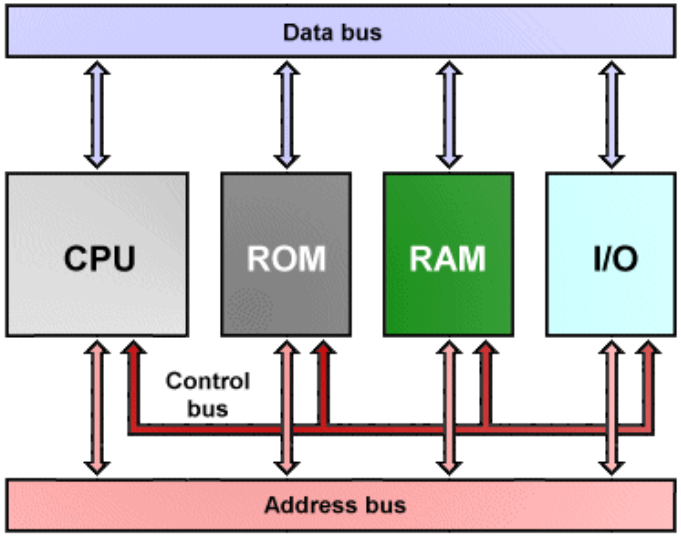
Chen Sun[1,2]*, Mark T. Wade[3]*, Yunsup Lee[1]*, Jason S. Orcutt[2]†*, Luca Alloatti[2], Michael S. Georgas[2], Andrew S. Waterman[1], Jeffrey M. Shainline[3]†, Rimas R. Avizienis[1], Sen Lin[1], Benjamin R. Moss[2], Rajesh Kumar[3], Fabio Pavanello[3], Amir H. Atabaki[2], Henry M. Cook[1], Albert J. Ou[1], Jonathan C. Leu[2], Yu-Hsin Chen[2], Krste Asanović[1], Rajeev J. Ram[2], Miloš A. Popović[3] & Vladimir M. Stojanović[1]

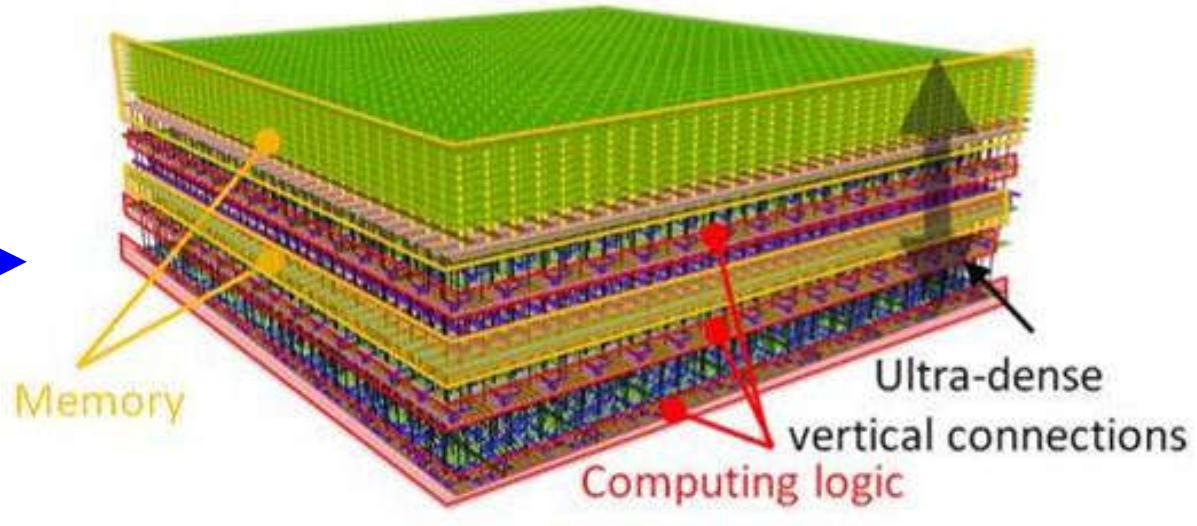


C. Sun, *et al.*, *Nature* **528,** 534 (2015)

3D IC

- **Logic + Memory + Sensing + ...**



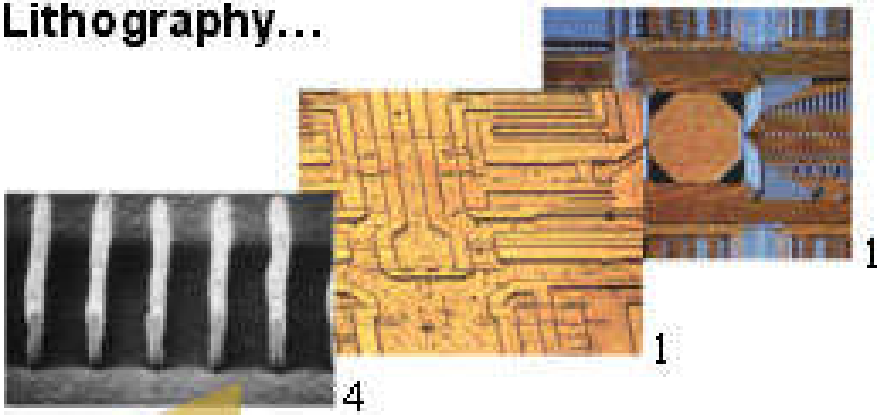


conventional **3D IC**

M. M. Shulaker, *et al.*, *Nature* **547**, 74 (2017)

Top Down vs. Bottom Up

Lithography…



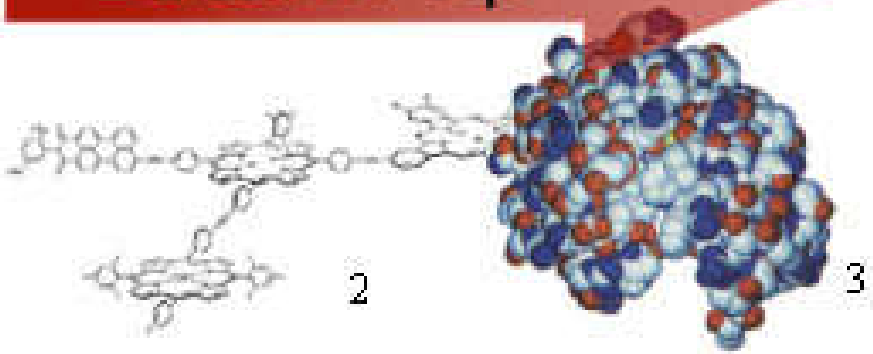
1

1

4

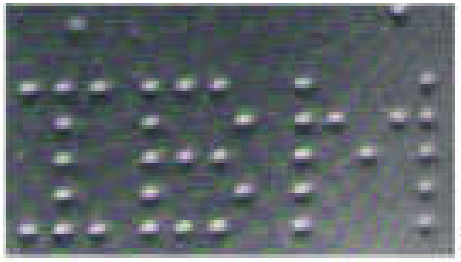
Bottom-Up

Top-Down



2

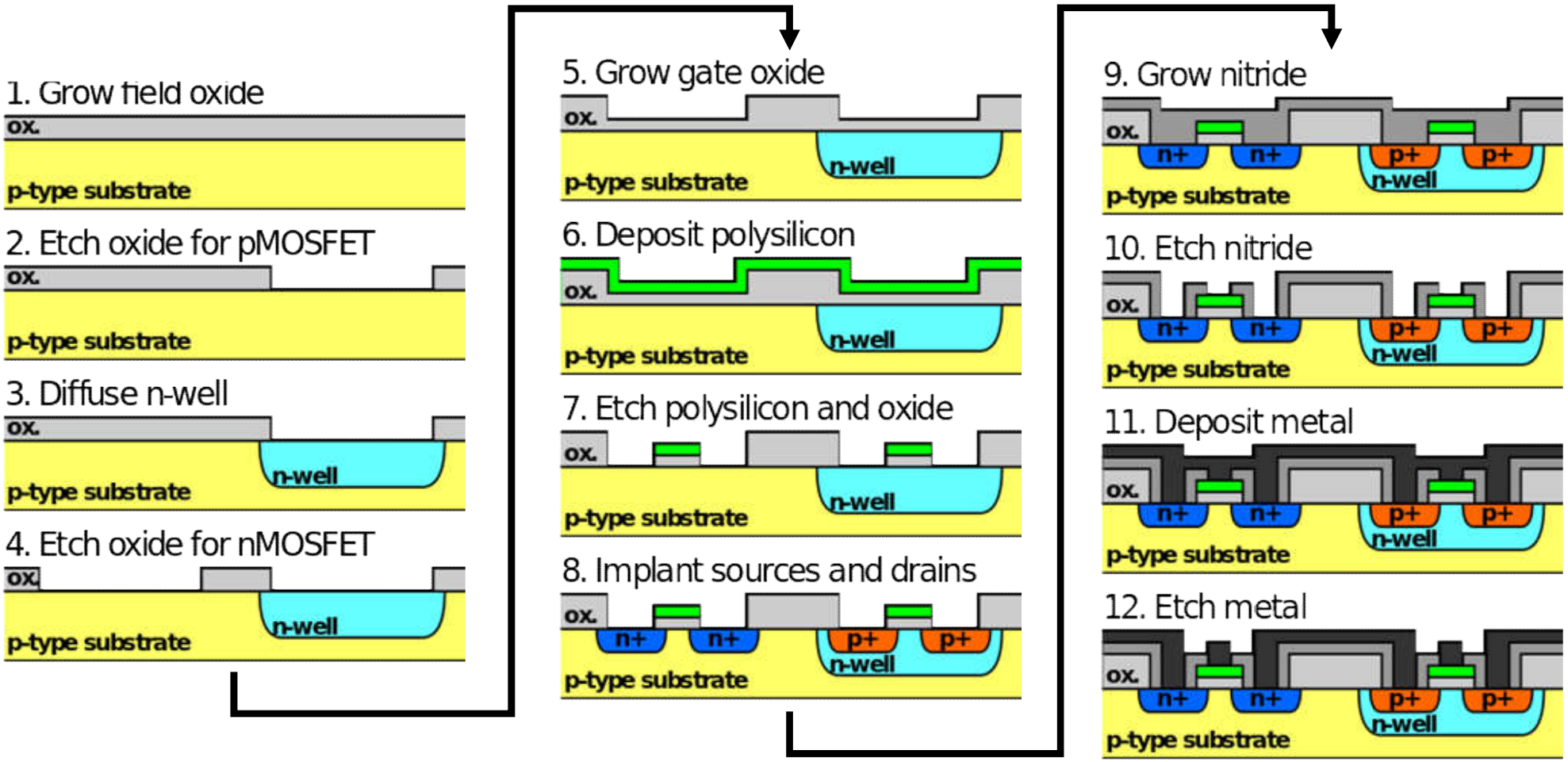
3



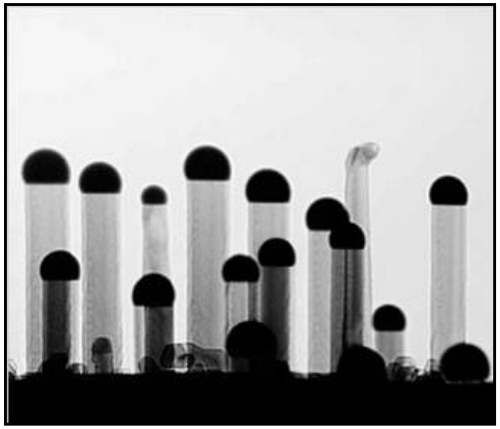
1

Synthetic Chemistry,
Genetic Engineering, …

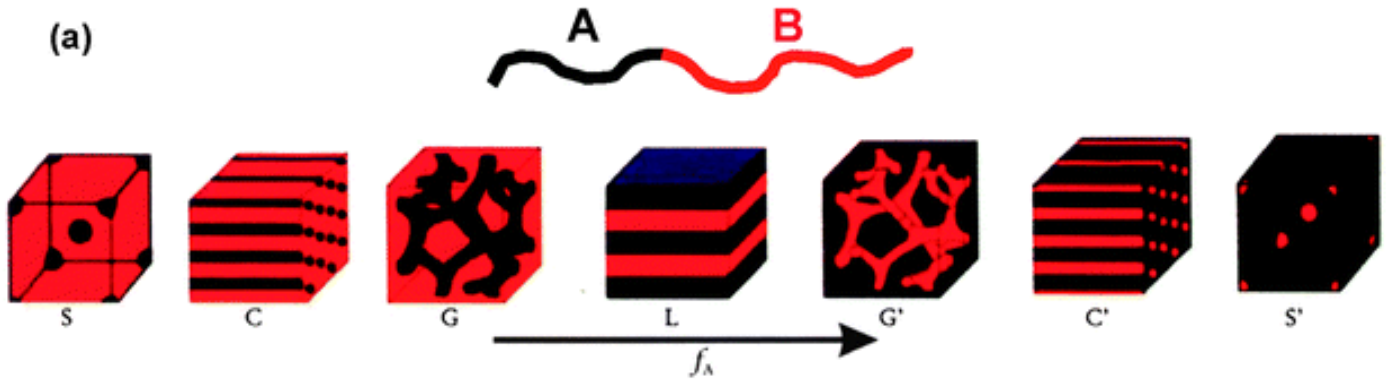
Top Down Approaches



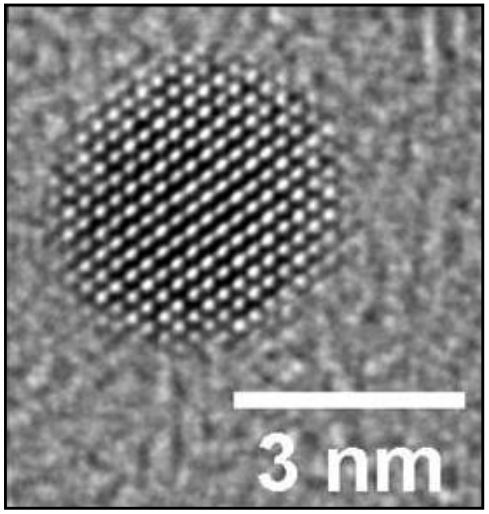
Bottom Up Approaches



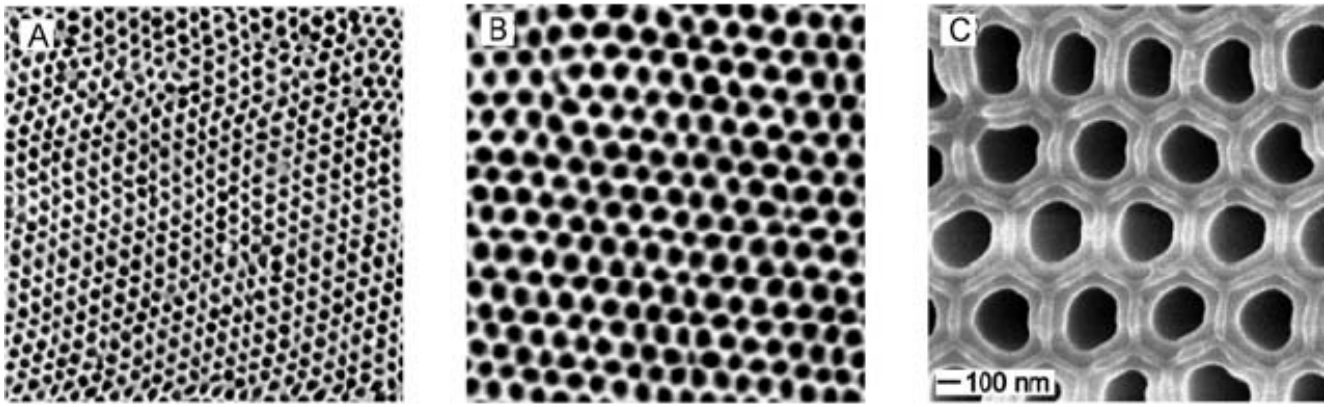
nanowire growth



block copolymer assembly



quantum dot



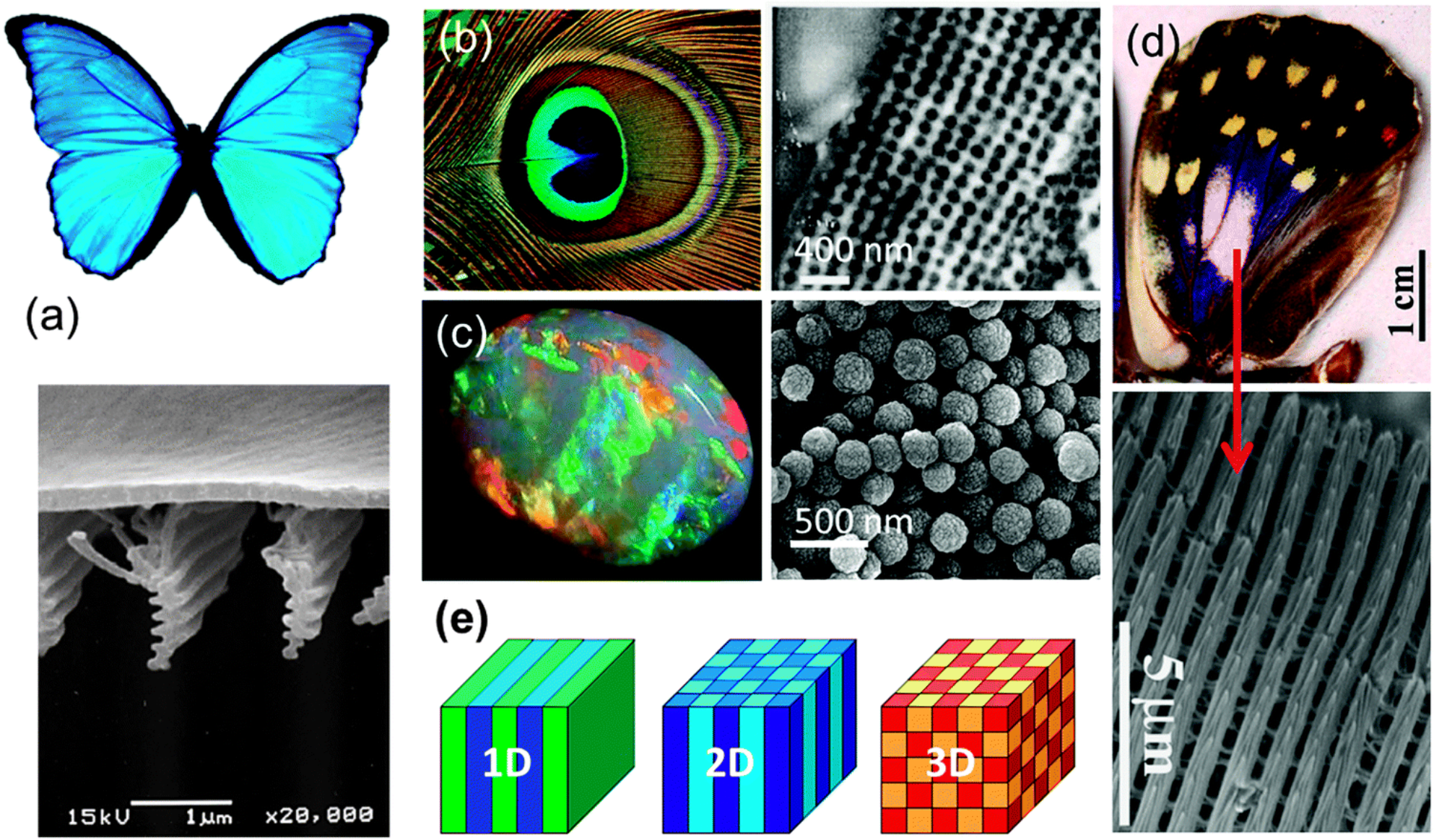
0.3 M H_2SO_4, 25 V
D_c = 60 nm

0.5 $C_2H_2O_4$, 40 V
D_c = 100 nm

1.1 M H_3PO_4, 160 V
D_c = 420 nm

anodized alumina

Nano Structures in Nature



E. Armstrong and C. O'Dwyer, *J. Mater. Chem. C* **3,** 6109 (2015)

Summary

"There is plenty of room at the bottom."

— Richard Feynman

"Scientists discover the world that exists;
Engineers create the world that never was."

— Theodore van Karman

Thank you for your attention