Introduction on My Current Research Interest

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Biography

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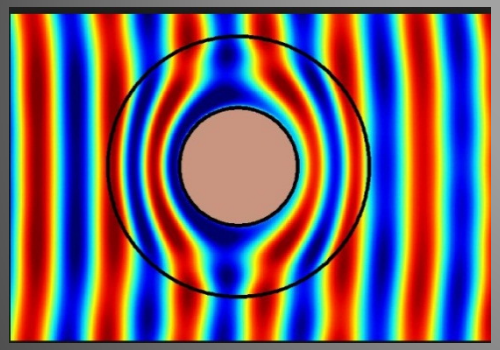
學經歷

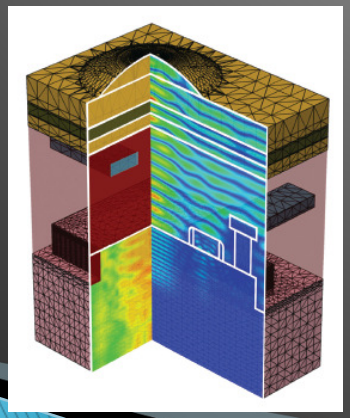
- EE, University of Michigan, Ann Arbor, PhD 2010
- EE, University of Michigan, Ann Arbor, MS 2007
- EE, National Chiao-Tung University, Taiwan, BS 2005

Current Research Interest

Silicon Nano-photonics



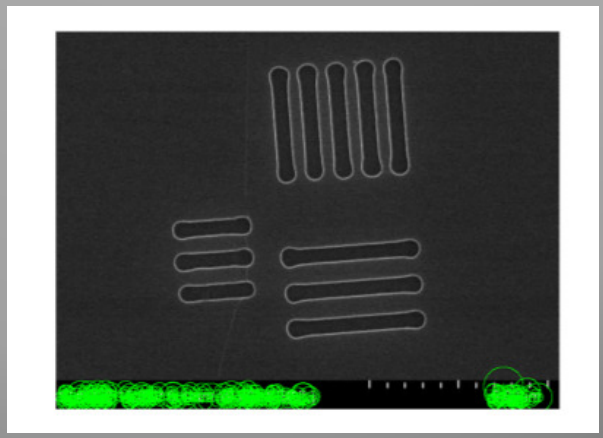
Device Simulation



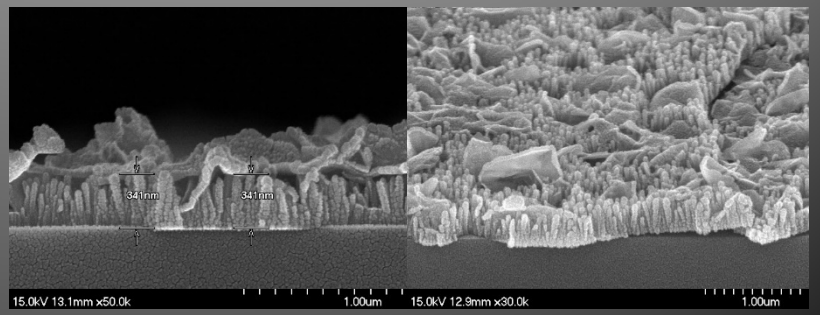
Ref: Sentaurus Device Manual

10.1109/JPHOT.2019.2938536

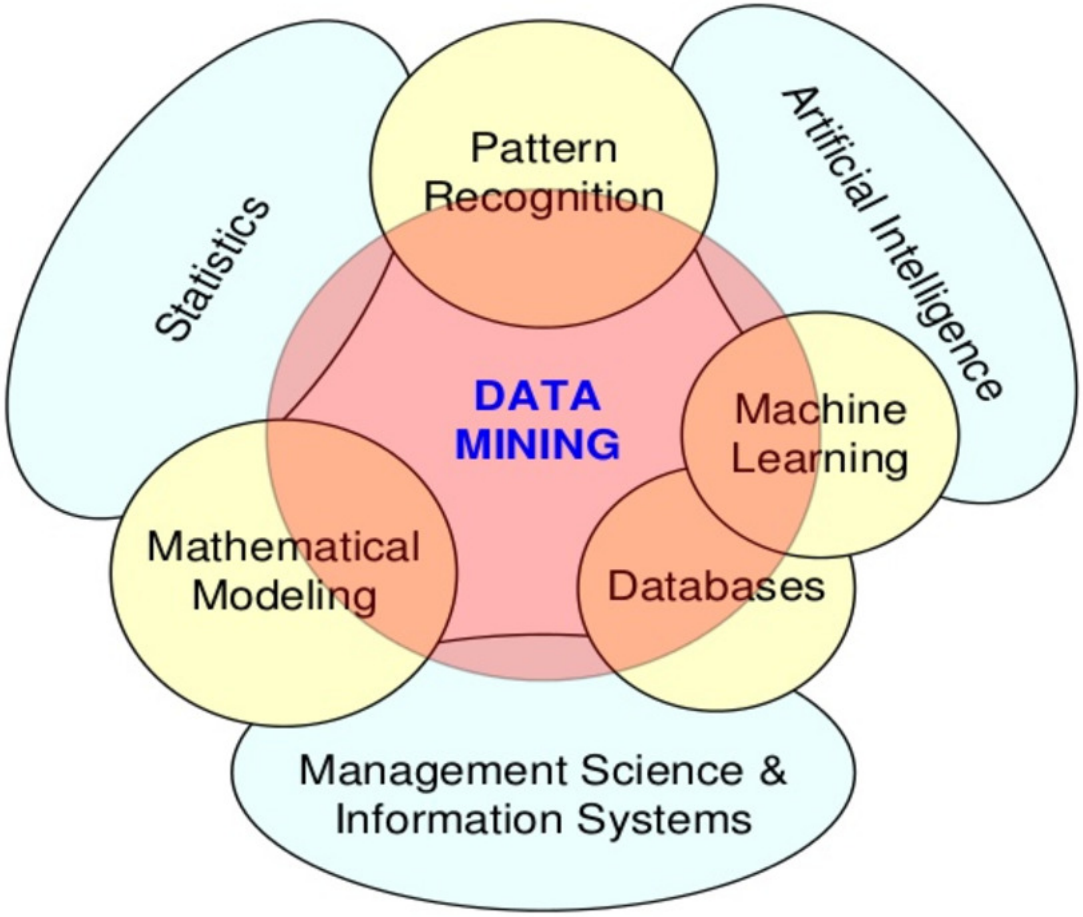
Intelligent semiconductor manufacturing



Device Process

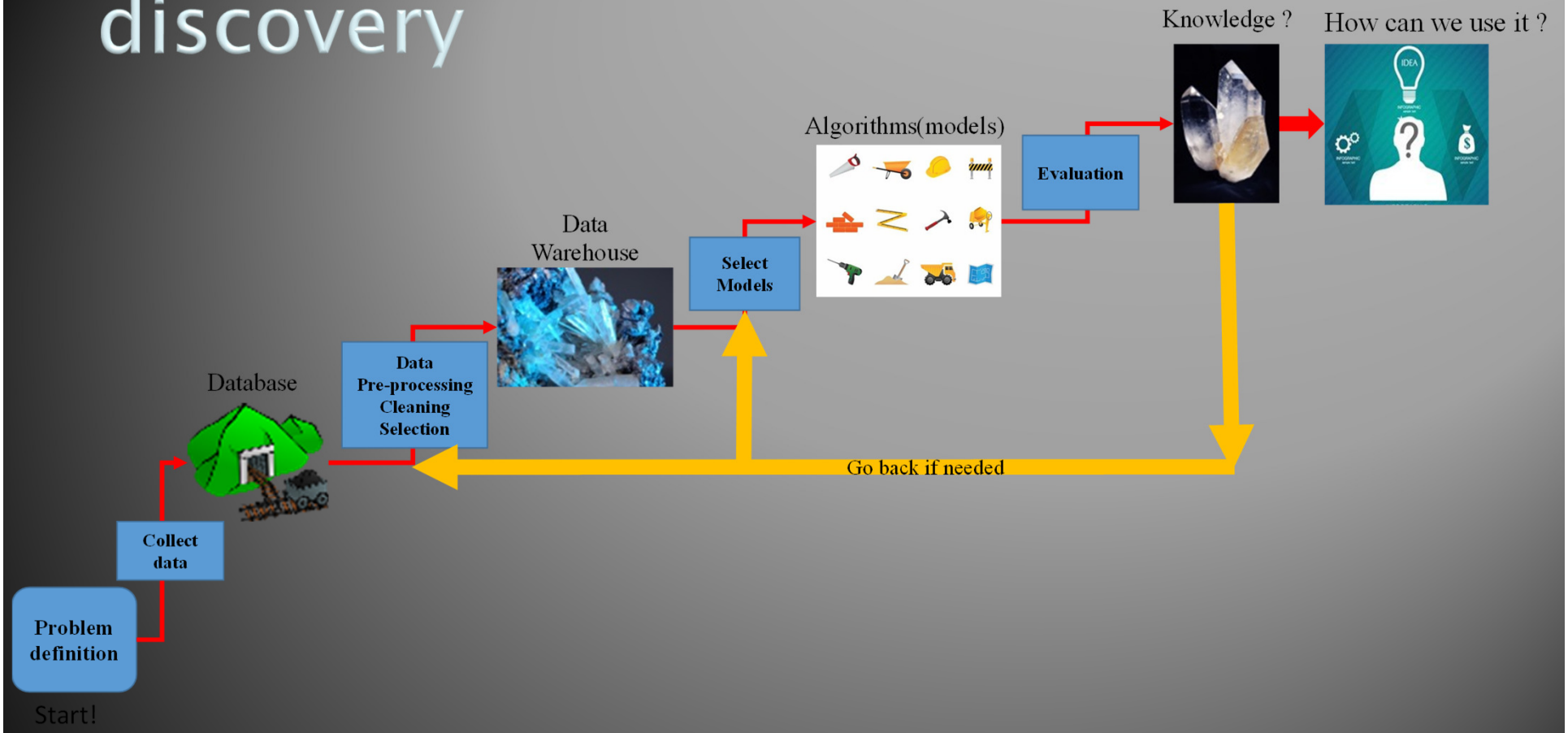


Relations between Data Mining & Machine Learning



Ref: https://www.slideshare.net/VisionGEOMATIQUE2014/gagnon-20141112v

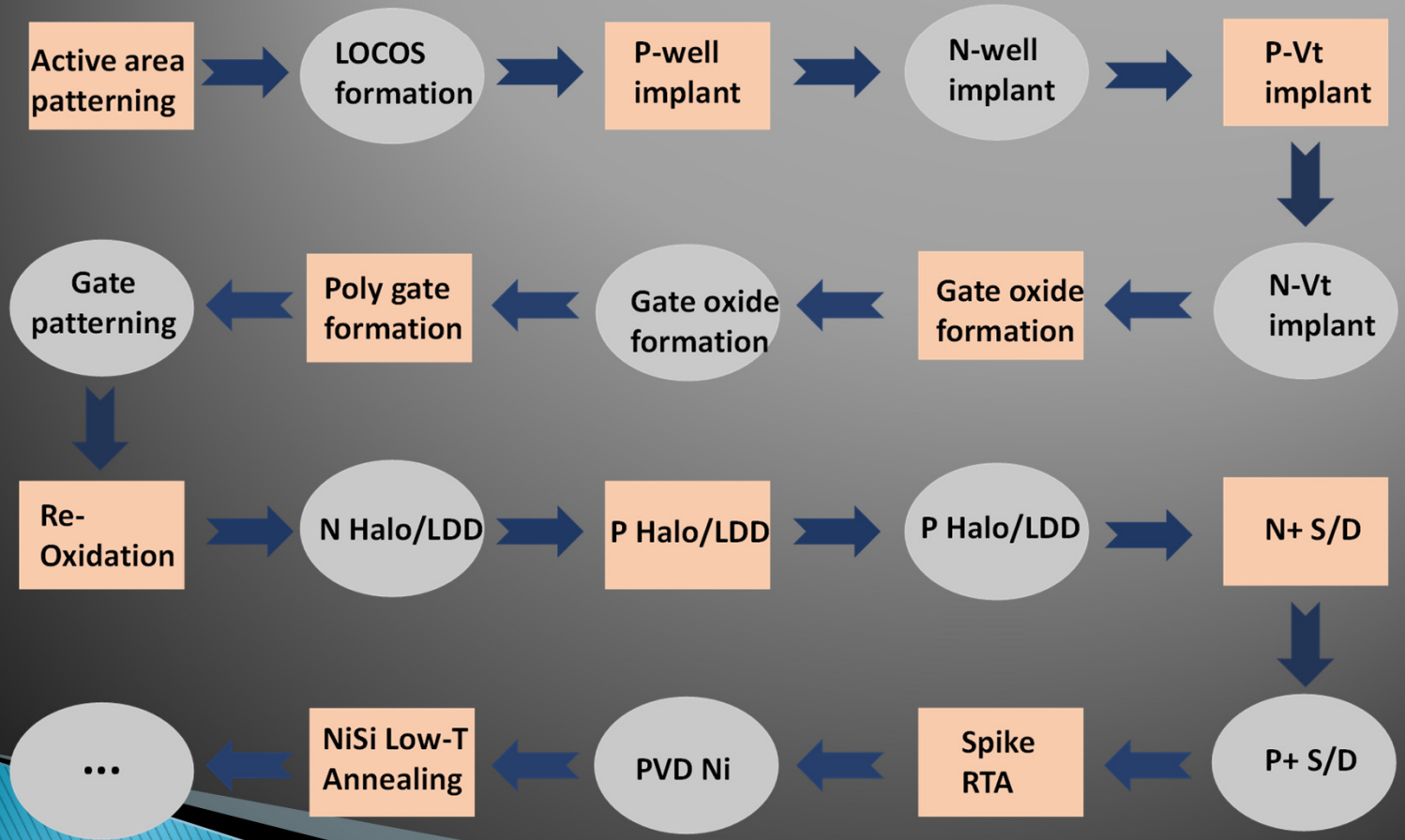
Data Mining: Process of knowledge discovery



Data mining steps

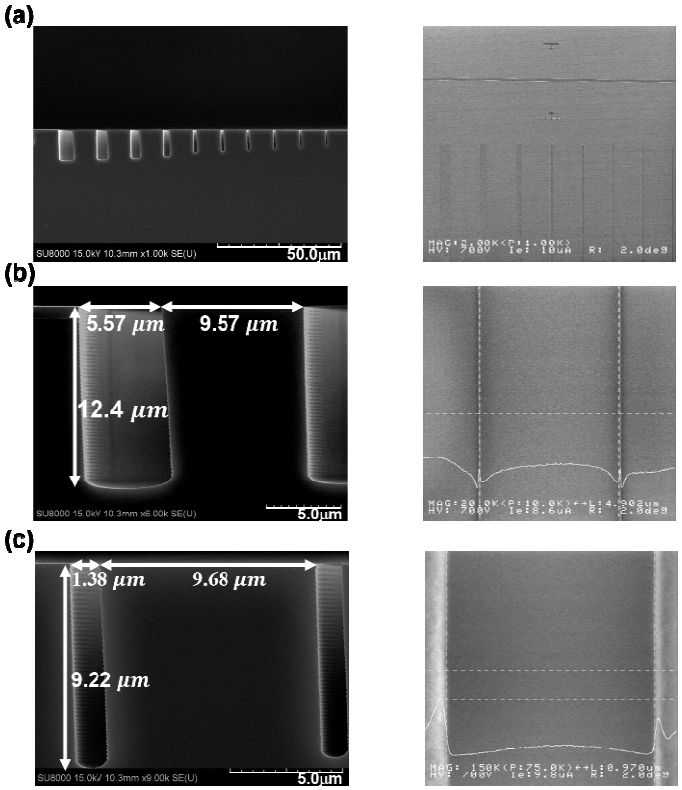
Data Mining in Semiconductor Processing

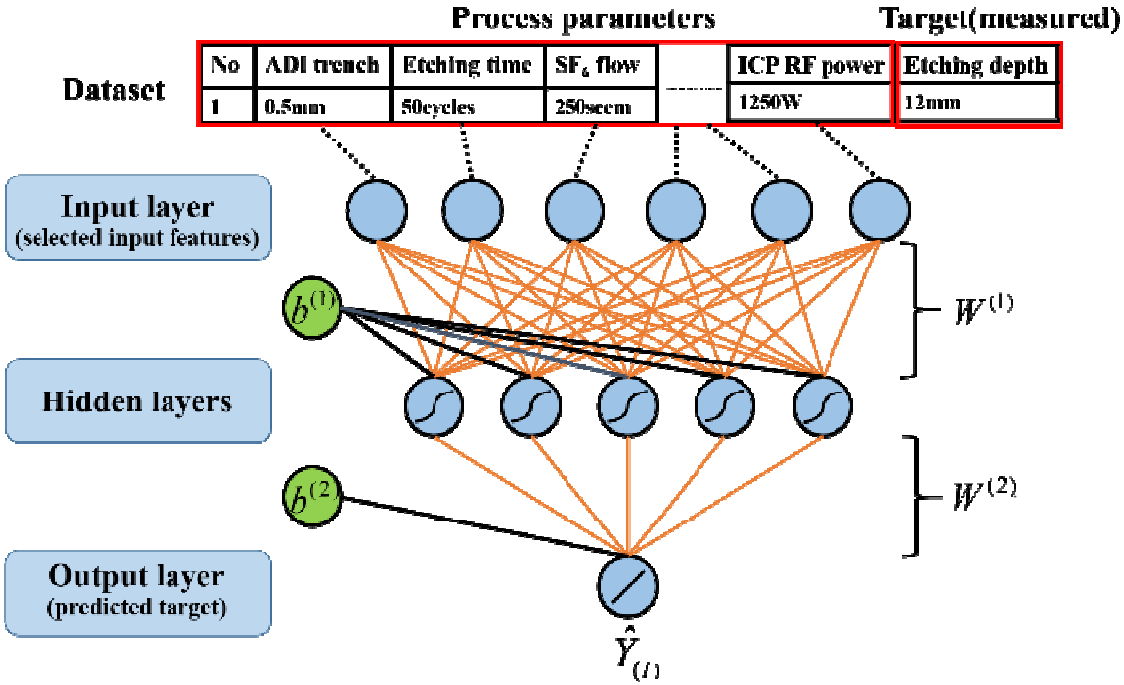
The Standard 90nm CMOS process require 150 steps and there are 1000+ parameters used during the whole process.



Data Mining in Semiconductor Processing

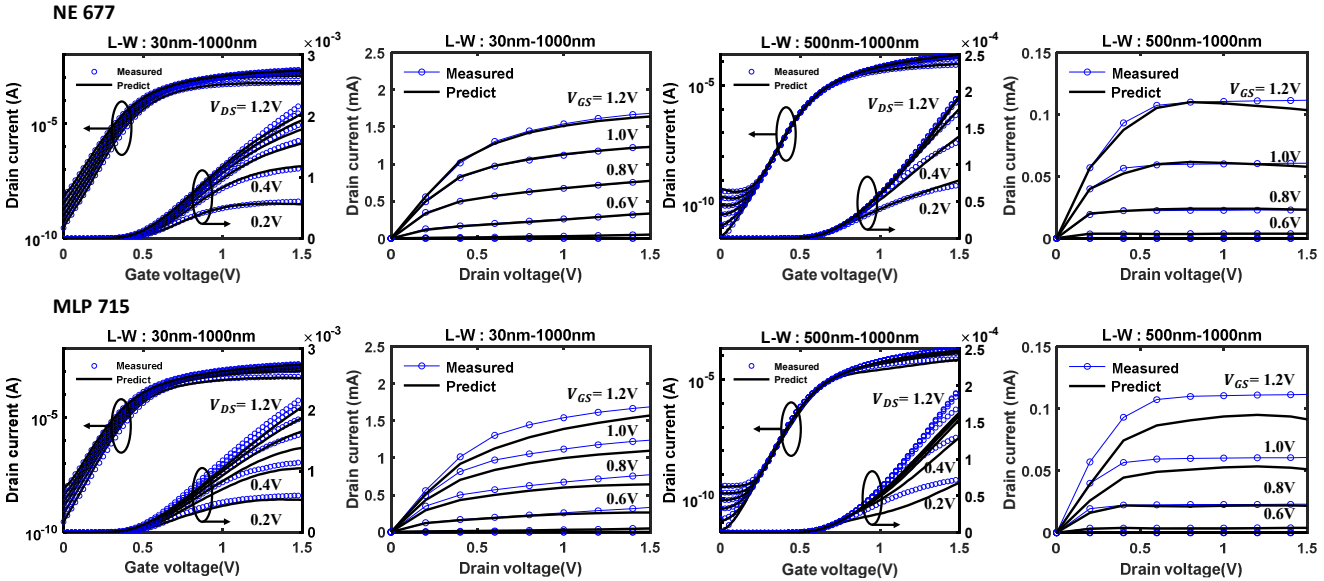
IEEE Access 7, 130168-130179

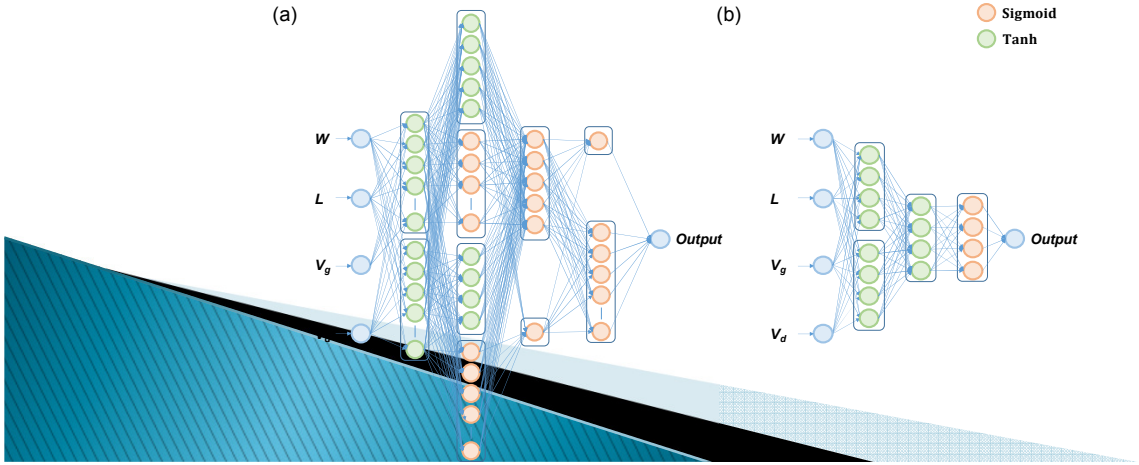




Data Mining in Semiconductor Processing

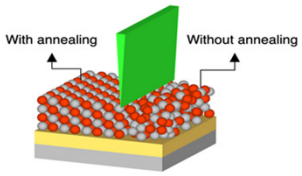
IEEE Access 9, 159048-159058

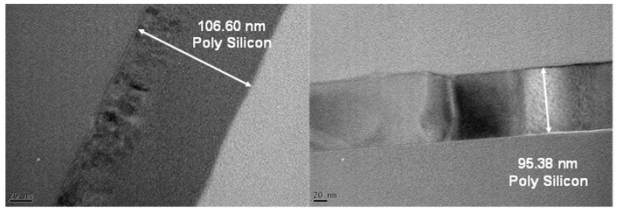




Data Mining in Semiconductor Processing

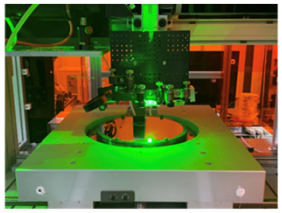
ACS omega 8 (1), 737-746

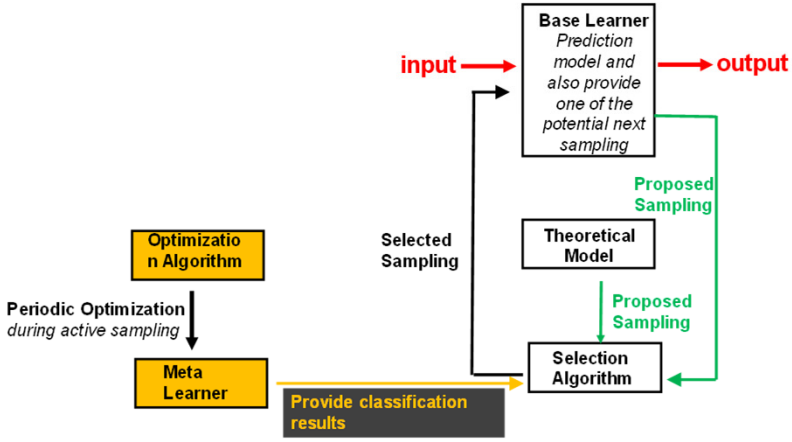




P 25keV 5E15 no annealing

P 25keV 5E15 GL 50kHz 6W room temperature





Meta Learner:
MLP(classification)

Optimization Algorithm:
Adam

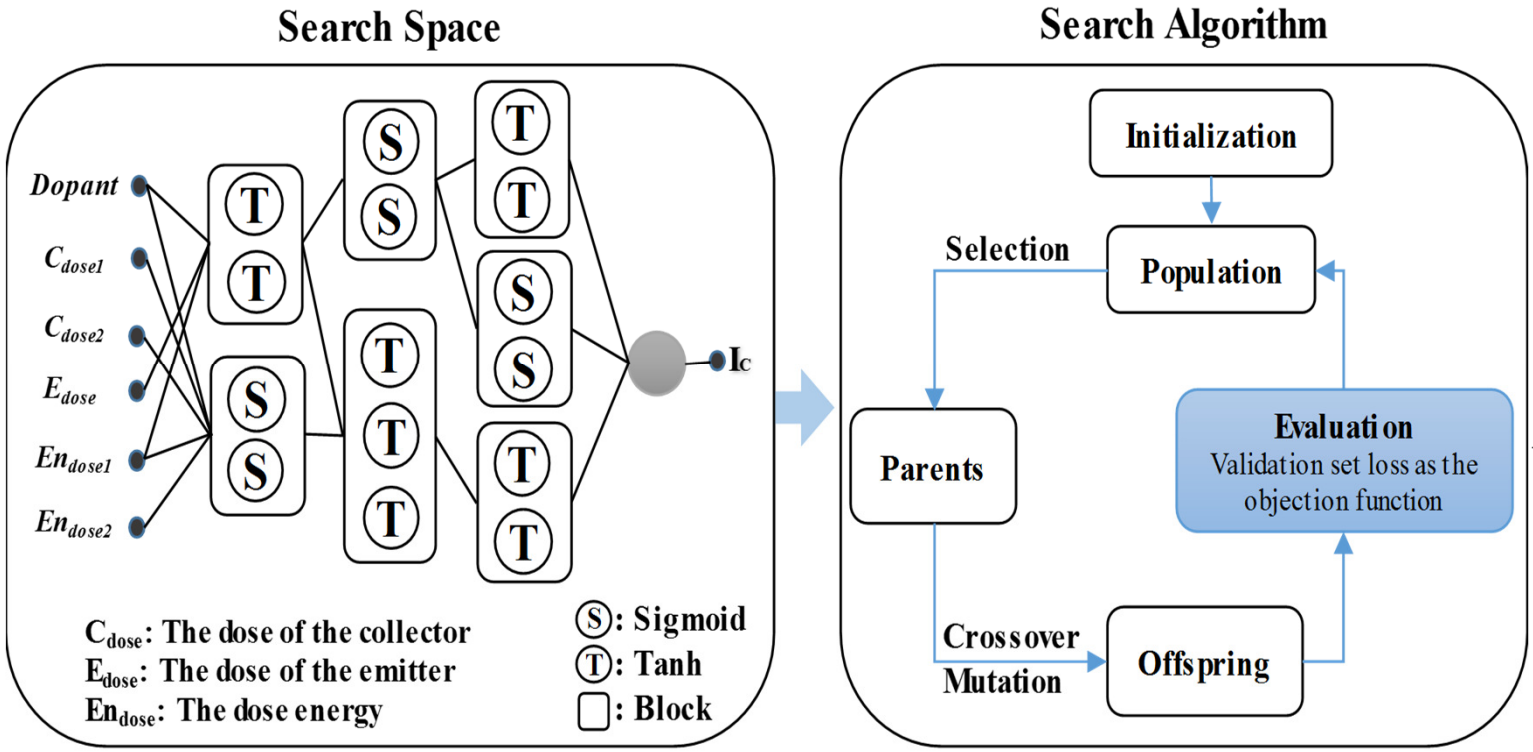
Base Learner:
MLP(regression)

Theoretical Model:
Heat Eq.+
Diffusion Eq.+
crystallinity phase Eq.

Selection Algorithm:
Based on simple
Classification results

Data Mining in Semiconductor Processing

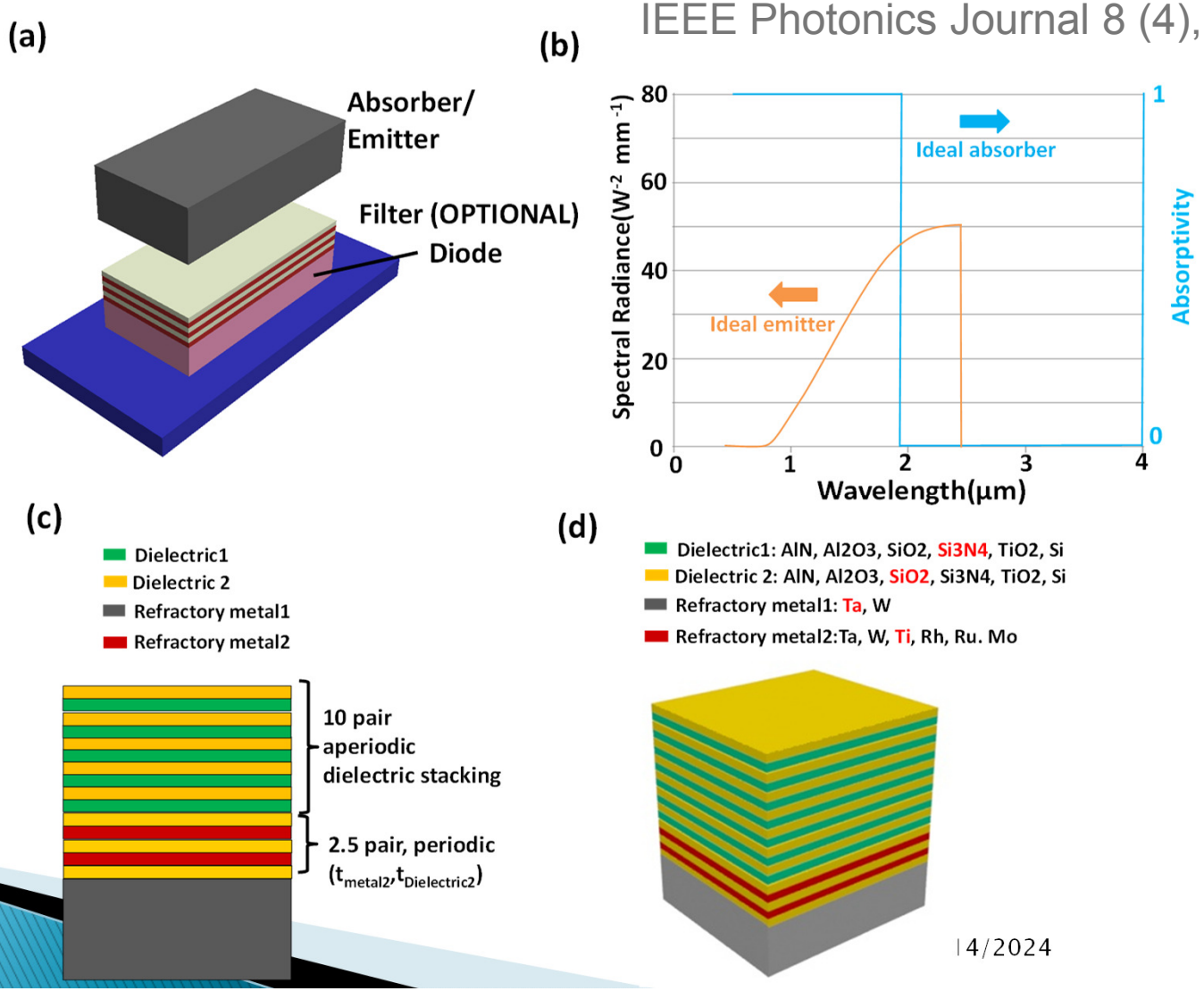
ACS omega 8 (31), 28877-28885



Silicon Photonics

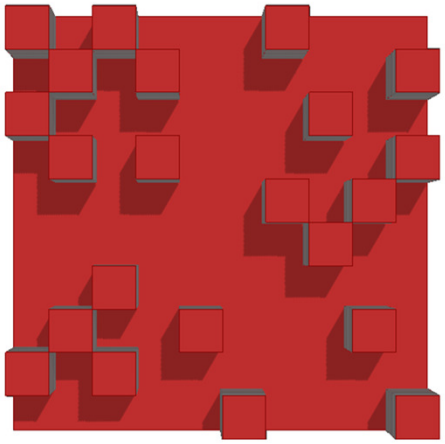
Thermo-photonics in silicon platform

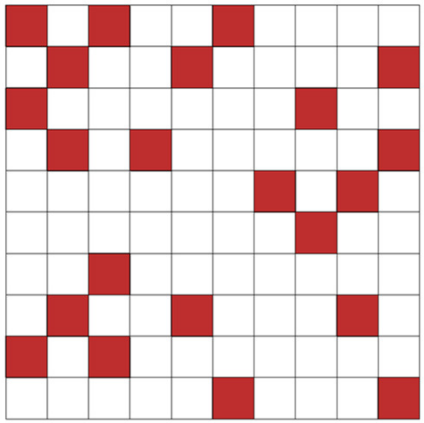
IEEE Photonics Journal 8 (4), 1-9

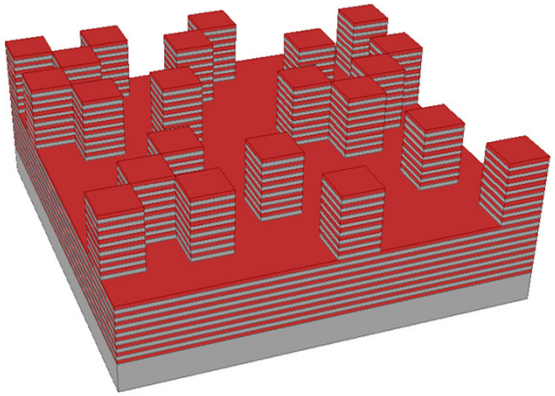


Silicon Photonics

Metamaterials in Silicon processing

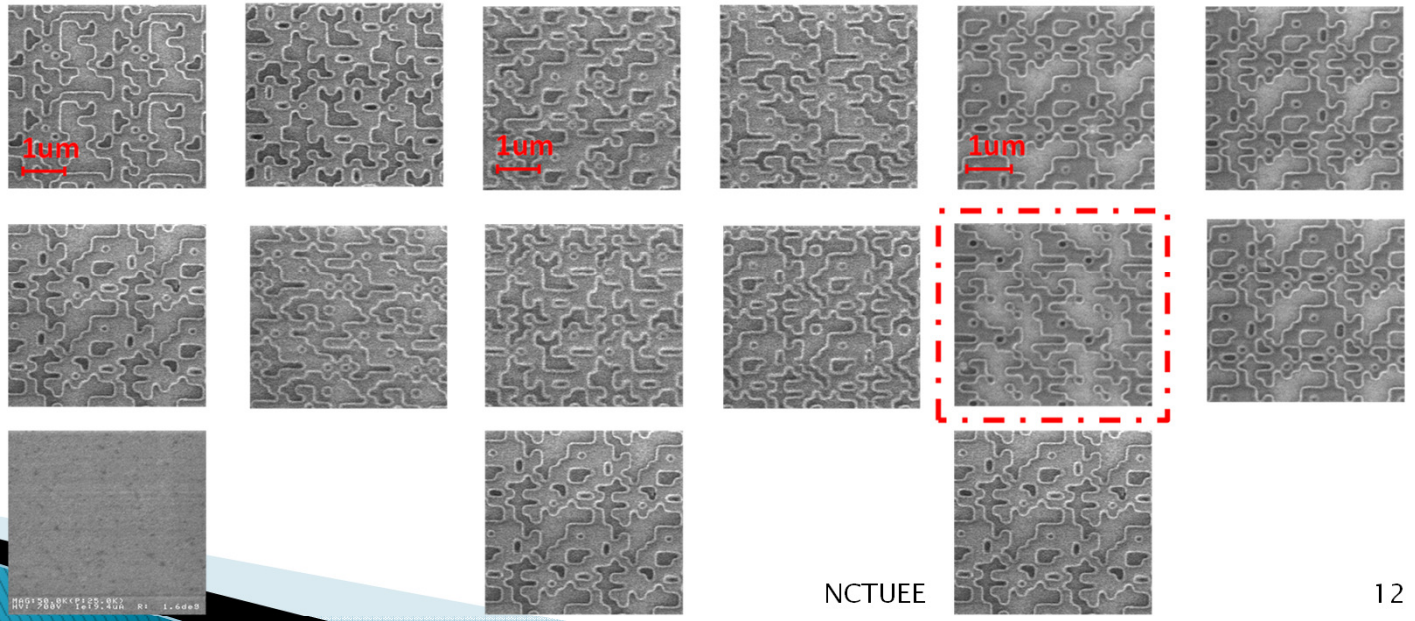






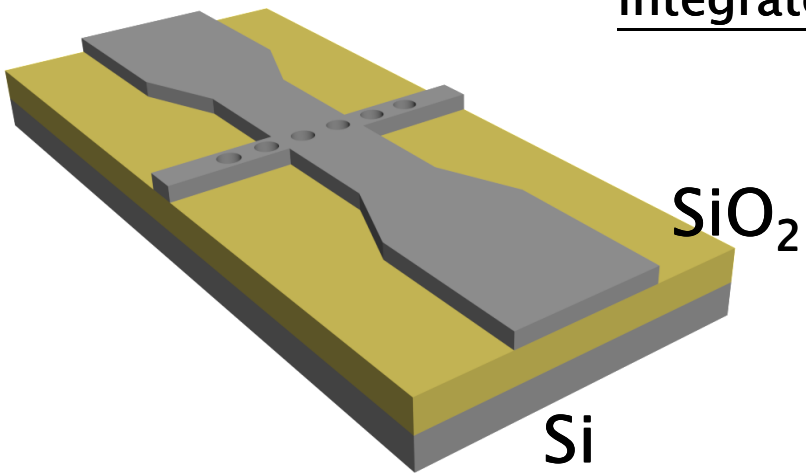
1st genearation　　2nd genearation　　3rd genearation

Optics Express 23 (19), A1324-A1333

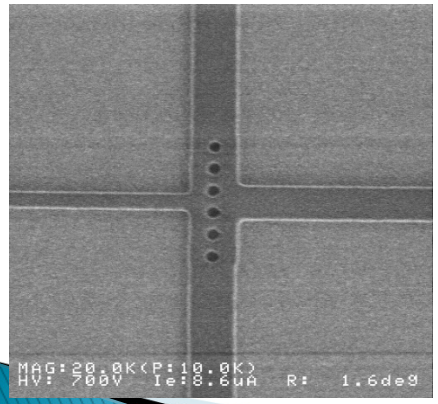


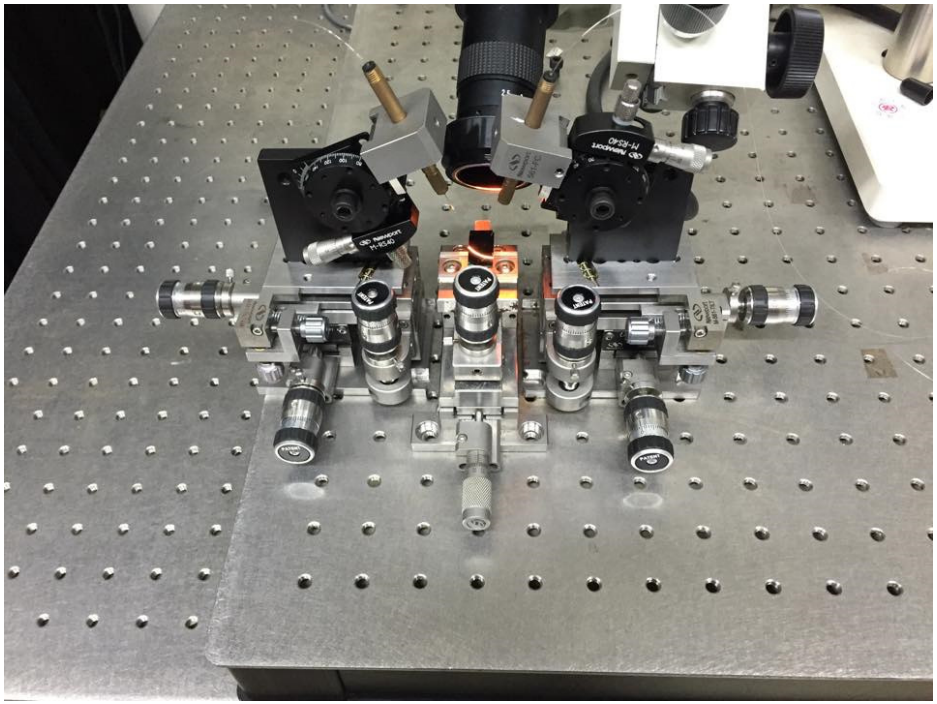
Silicon Photonics

Integrated Silicon Photonics



3D structure figure





Description to Drift-Diffusion Model for IBSC

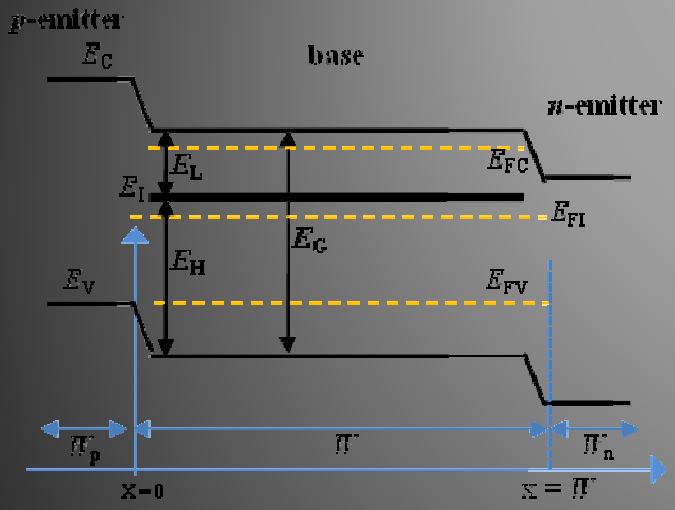


Illustration of the prototype intermediate band solar cell device structure and energy band diagram.

Effect of charge in intermediate band

$$\vec{\nabla}\cdot\varepsilon_r\varepsilon_0\vec{\nabla}\psi = q\left(N_A^- - N_D^+ + n - p - fN_I\right)$$

$$\vec{\nabla}\cdot\vec{J}_n = q\left(G_{VC} + G_{IC} - R_{CV} - R_{CI} - R_{nr}\right)$$

$$\vec{\nabla}\cdot\vec{J}_p = q\left(G_{VC} + G_{VI} - R_{CV} - R_{IV} - R_{nr}\right)$$

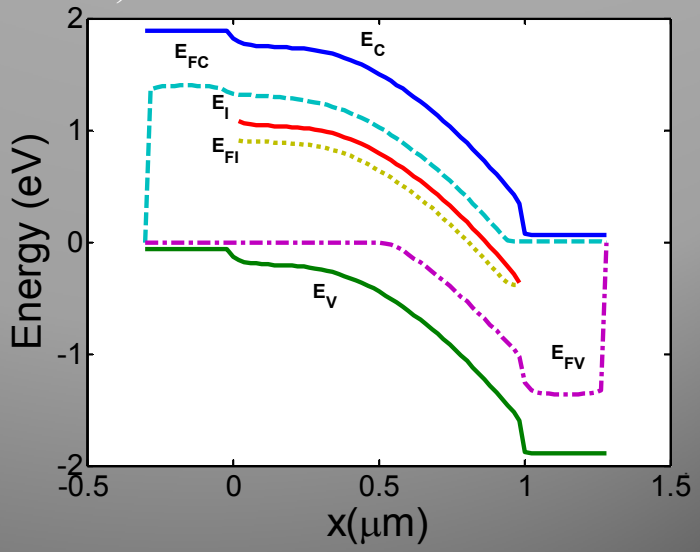
Where ψ is electrostatic potential, n and p are electron and hole concentration. f is the filling of the intermediate band. N_I is the IB density of states.

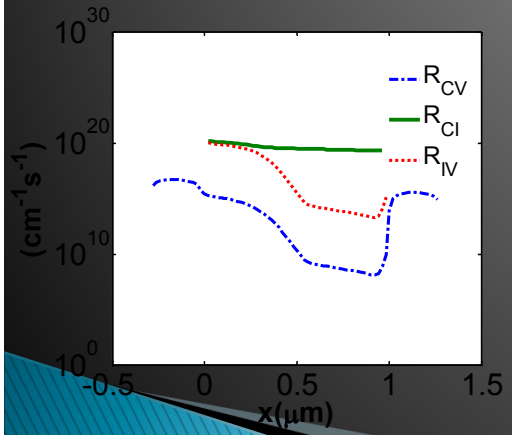
This cannot be simply incorporated into existing drift-diffusion model

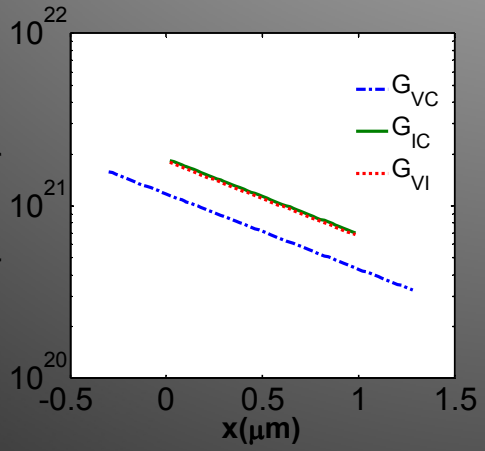
Lightly Doped Case

- E_{FI} is significantly below E_I , predicted high efficiency may not be achievable in practice unless
  - ✓ Asymmetric optical absorption cross section
  - ✓ efficient field emission or thermionic field emission exist between IB and CB.

$\alpha_{VC} = \alpha_{IC} = \alpha_{VI} = 10^4$ cm^{-1}, $E_G = 1.95$ eV, $E_I = 1.24$ eV $\mu_n = \mu_h = 100$ cm^2/Vs, $W = 1$ μm, $N_I = 10^{18}$ cm^{-3} and N_A (p-emitter)$=N_D$ (n-emitter)$= 10^{18}$ cm^{-3}

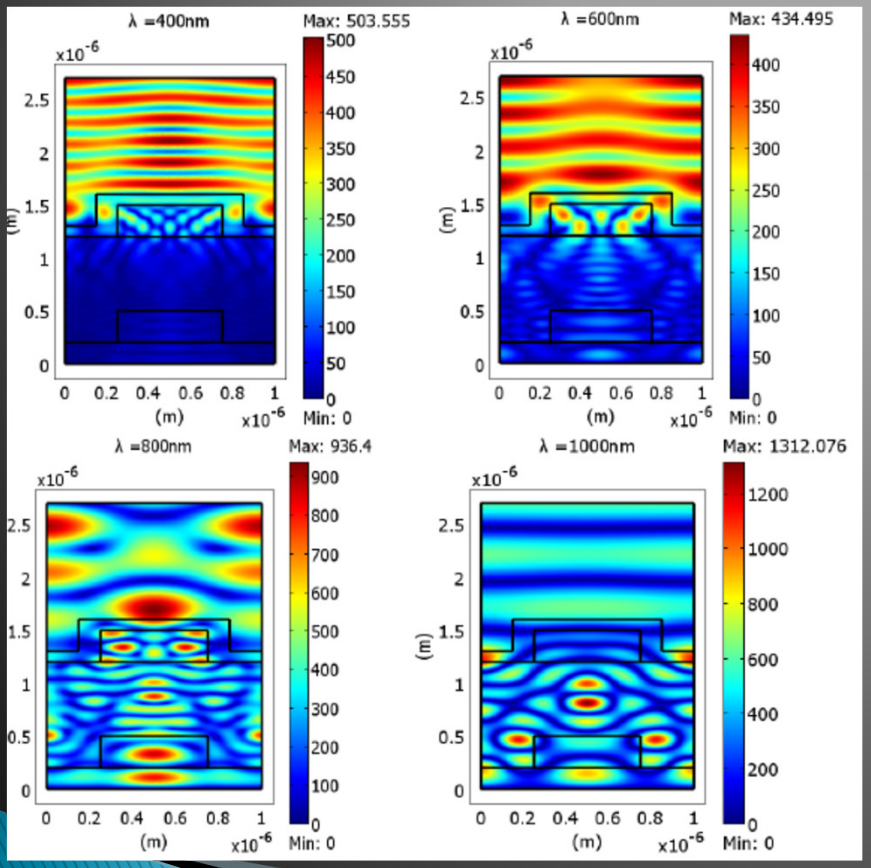






- The band diagram deviate from conventional *p–i–n* (*p–π–n*,*n p–υ –n*) type picture, resulting from the charge in the intermediate band

Periodic Grating Structure



Electric field profile for cells with periodic grating couplers

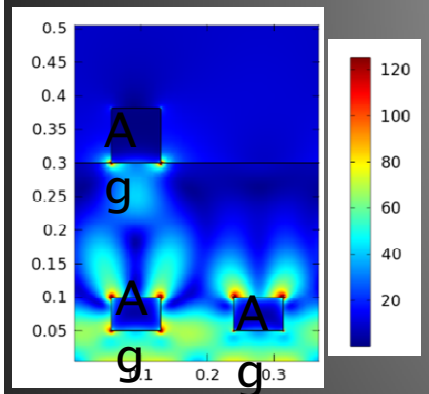
Helmholtz equation is solved for E-field

$$\nabla^2 E_z(\vec{r}) + \omega^2 \mu \varepsilon E_z(\vec{r}) = 0$$

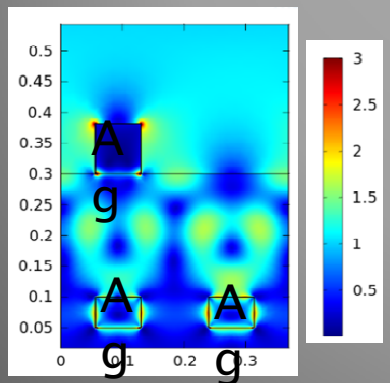
- For $\lambda = 400\ nm$, the incoming wave decays rapidly in device
- For $\lambda = 1000\ nm$, wave bounces back and forth

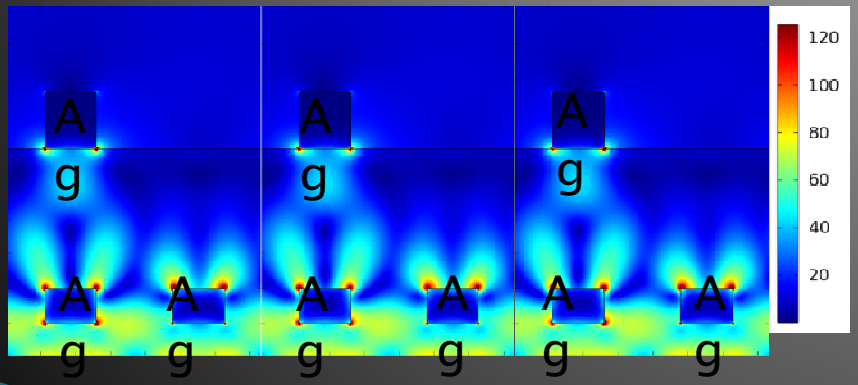
Surface Plasmon Photovoltaics

Field Profile

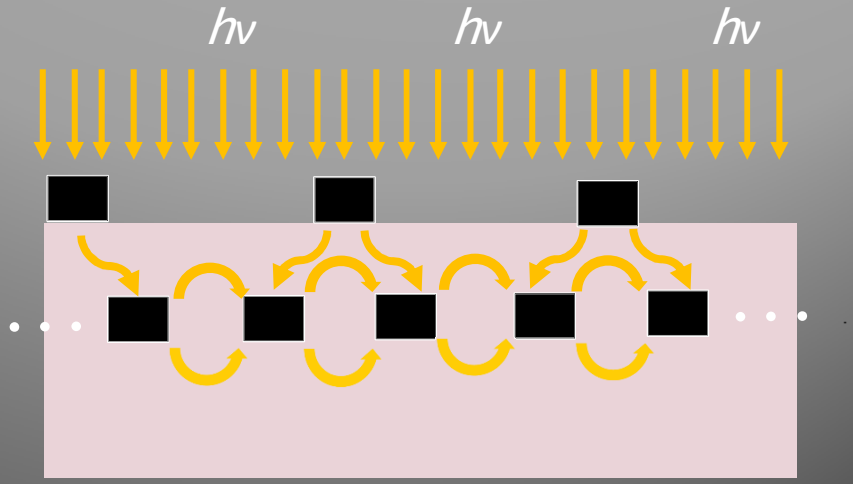


Eigen mode





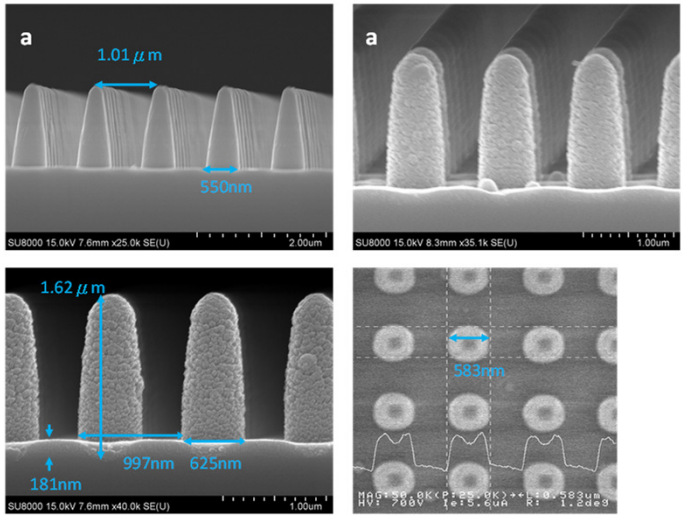
- ✓ Using Surface Plasmon to increase solar cell photonic property
- ✓ Waveguiding, slow light, slow Bloch mode, and energy transfer



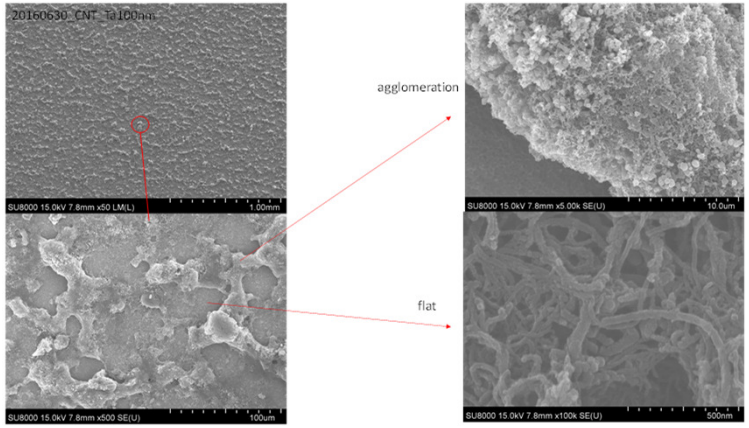
Device Processing

Silicon Processing

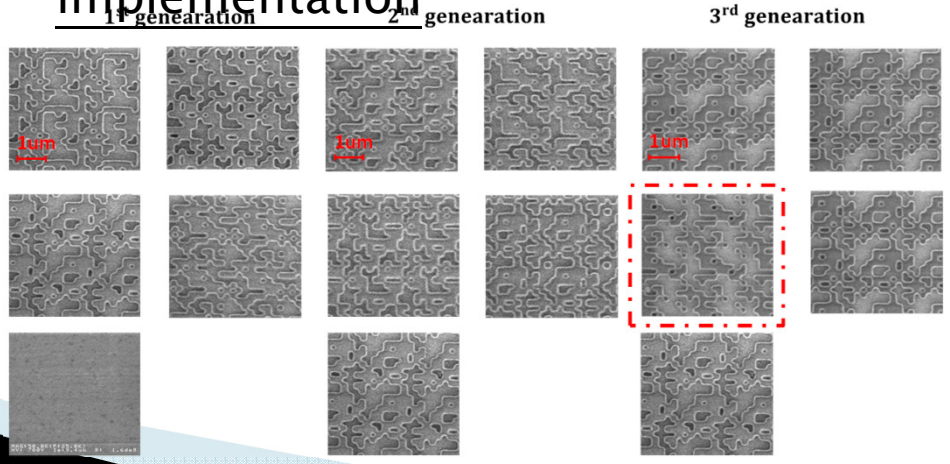
Paper figure (Taper structure 300-1000)



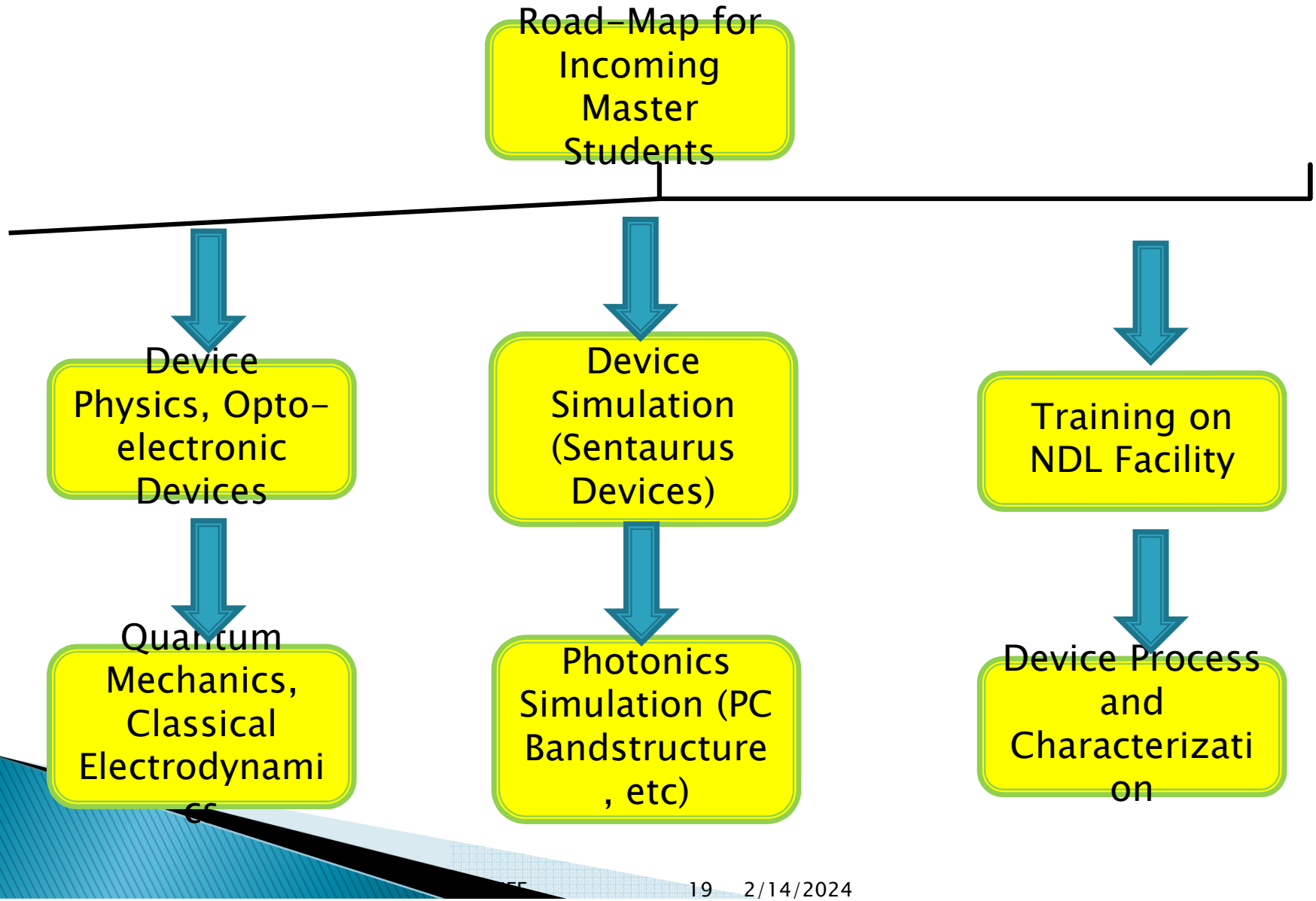
Material Processing



Advanced mask design and implementation



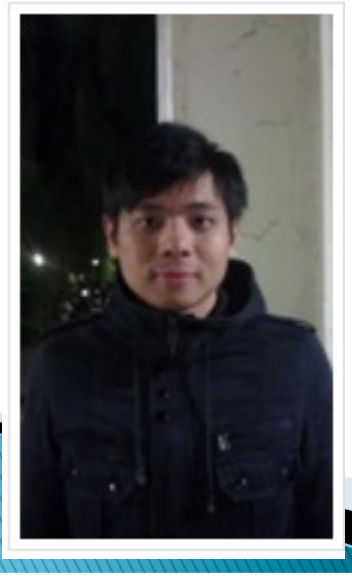
Theoretical and Process in parallel



Direct PhD, great theorist , TSMC

Excellent
IIT exchange student

Graduate in 1 year, process integration TSMC



Direct PhD , and my first PhD student, Sze-Ming Fu

Thank you,
and Welcome your visit!

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