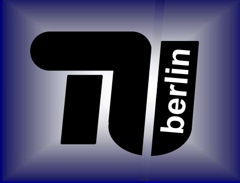


Nanoscale Resolution Options for Optical Localization Techniques

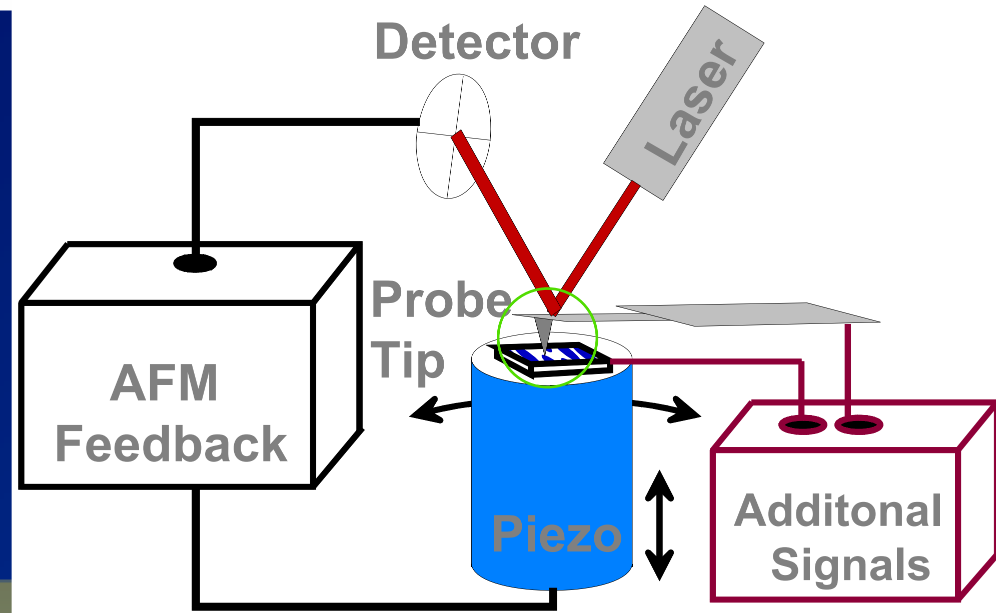
C. Boit

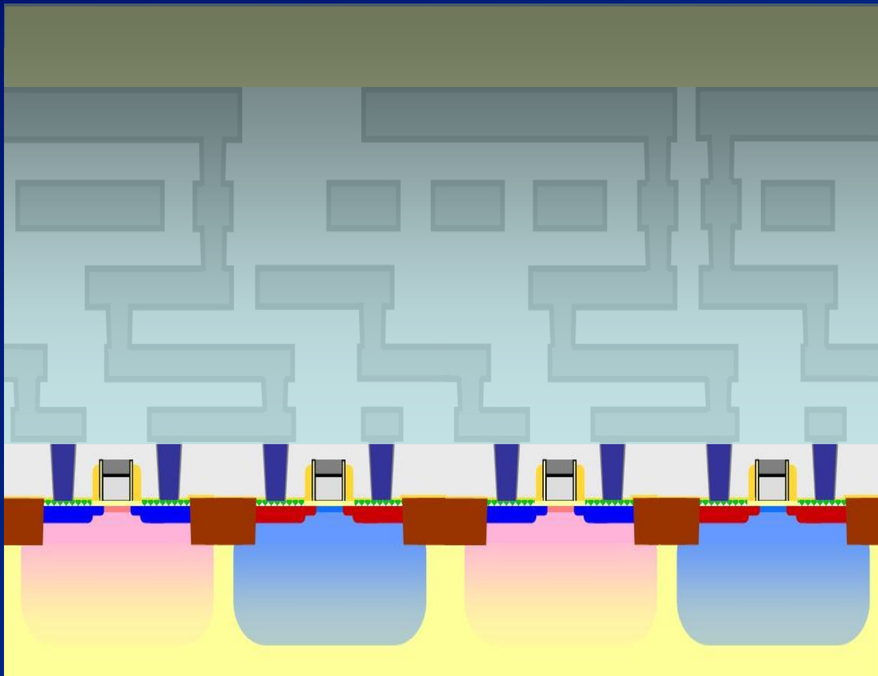
TU Berlin – Chair of Semiconductor Devices

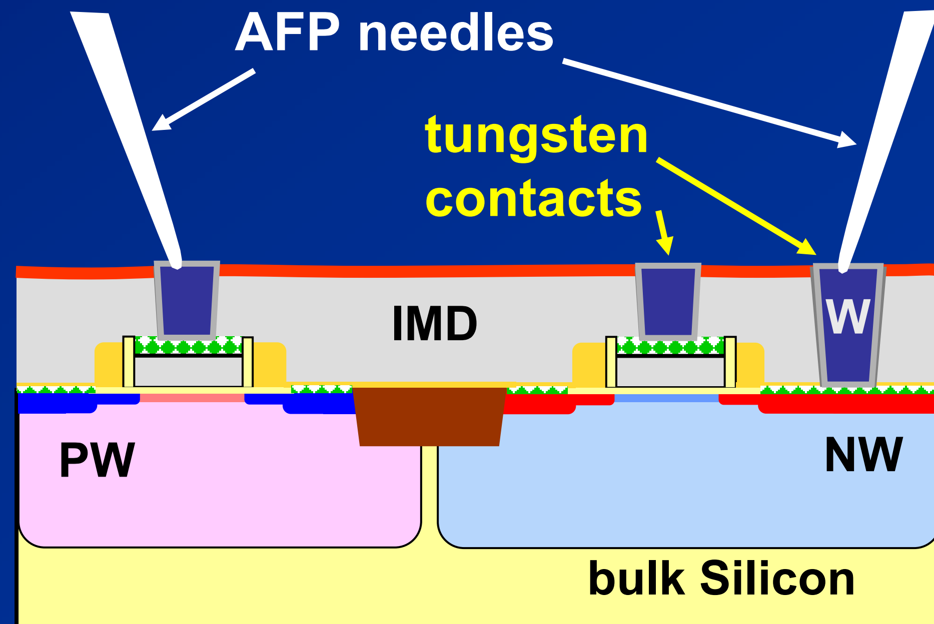
EUFANET Workshop on Optical Localization Techniques
Toulouse, Jan 26, 2009

Nanoprobing of Identified Node

- Resolution < 50nm
- Parallel lapping down to contact layer
- Isolated devices
- Low ohmic contact
- Destructive to circuit





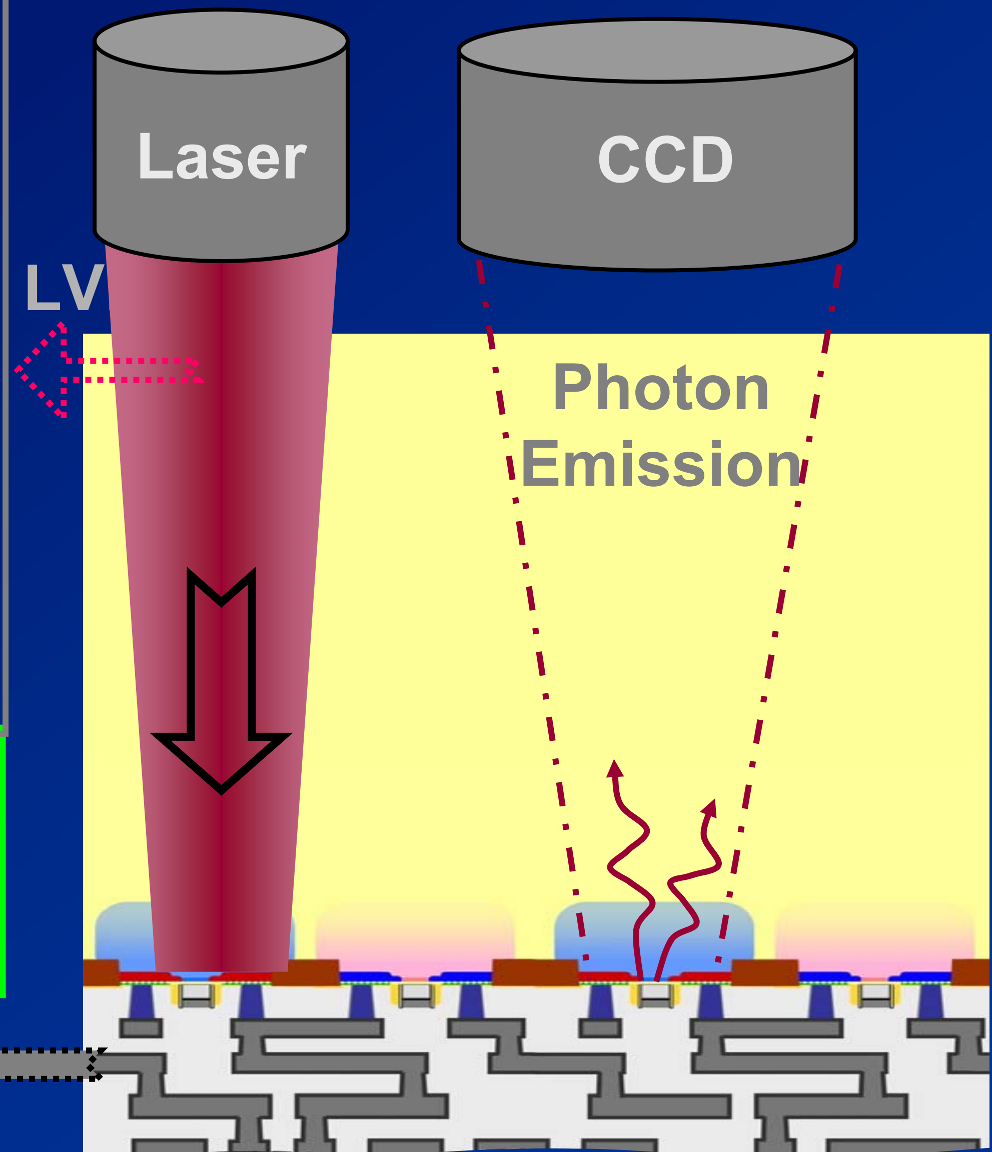


Optical Backside Circuit Analysis

- GHz regime managed by most dynamic techniques
- Feature Size Resolution: 2 levels of analysis
  - Level 1: IR + SIL to identify critical area
  - Level 2: Nanoprobing to verify critical node
  - prep circuit destructive

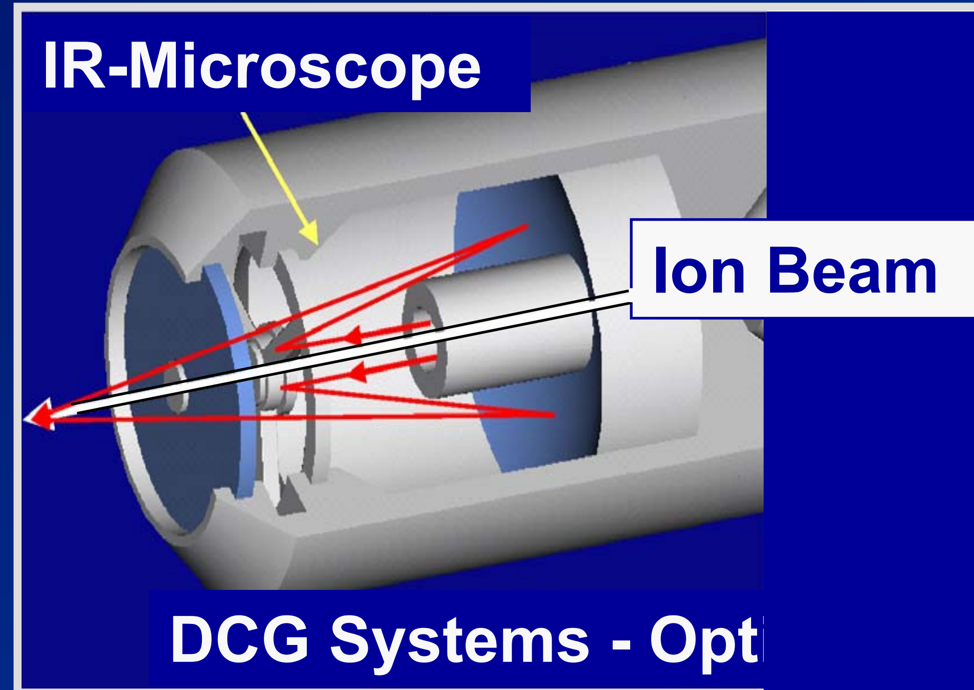
increasing need for a high resolution optical localization technique

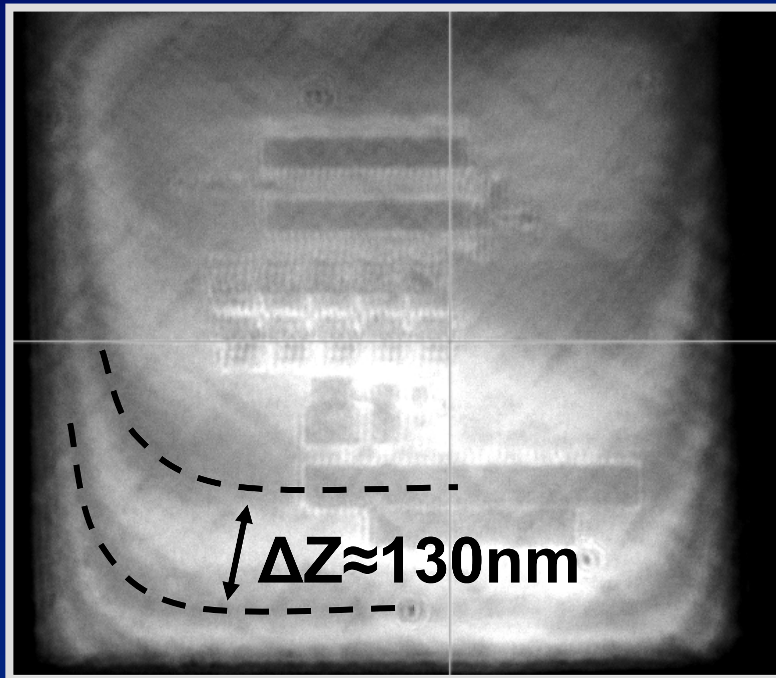
Laser Stimulated Electrical Signal



Trench Floor Planarity

Global navigation through silicon with co-axial IR and ion column

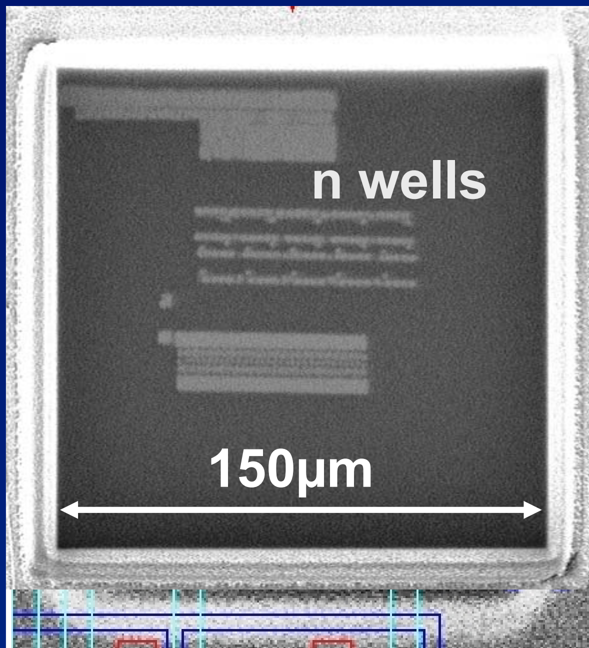




Co-planarity check of trench bottom to chip levels with interference rings (fringes)

FIB Ultra Thin Back Surface Procedure

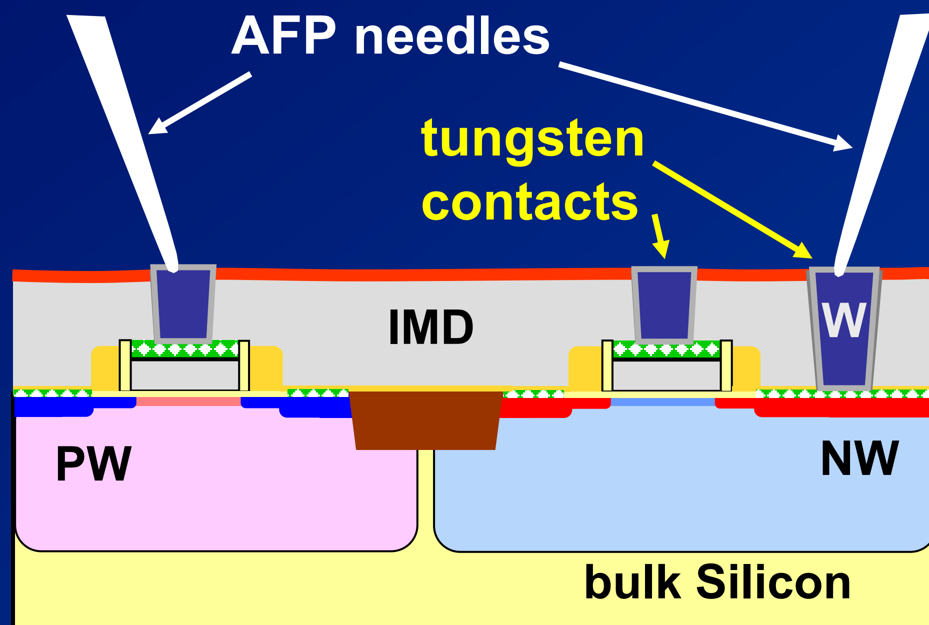
- **mechanical thinning**
- **localized FIB trench**
  - **1st endpoint on n-wells – voltage image contrast**
  - **2nd endpoint on STI – material image contrast**
    - **< 400nm remaining Si**
- **local high precision alignment**

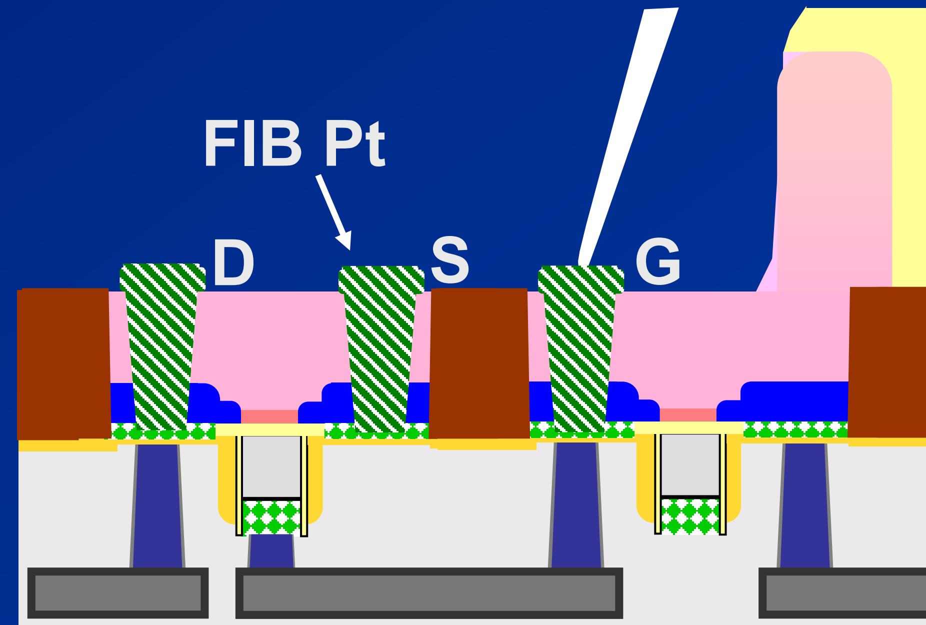


frontside AFP backside

- parallel lapping down to contact layer
- isolated devices
- low ohmic contact
- Destructive to circuit

- FIB backside process
- devices not isolated
- creation of new circuit nodes
- Circuit fully functional

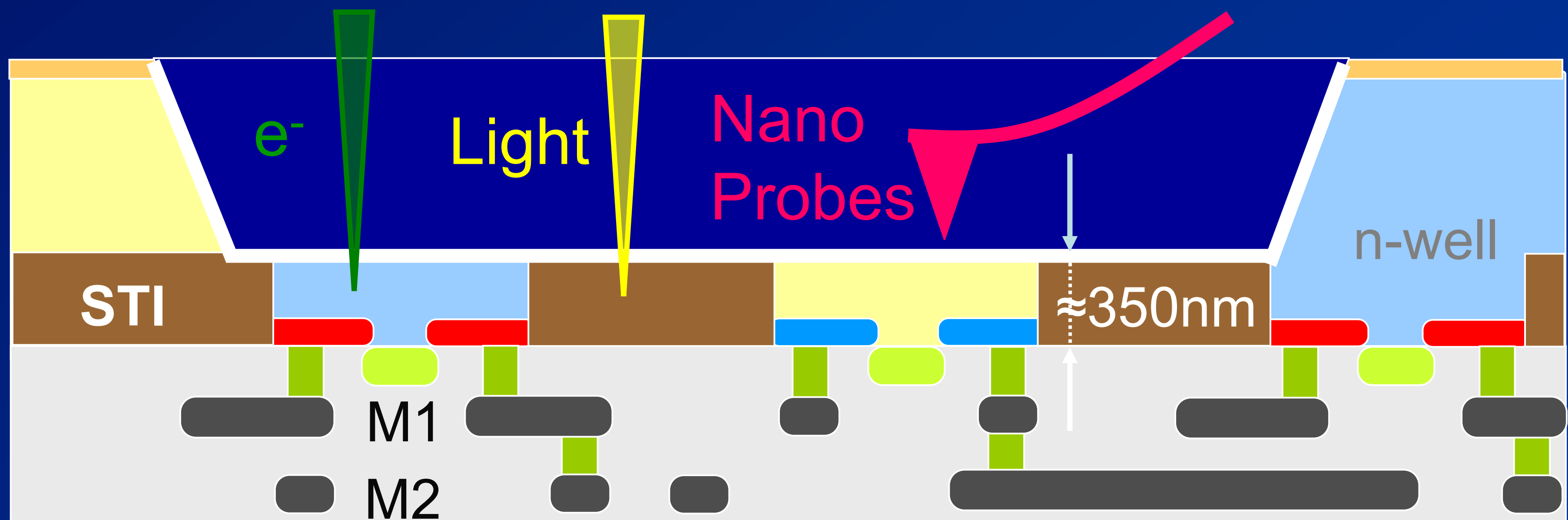




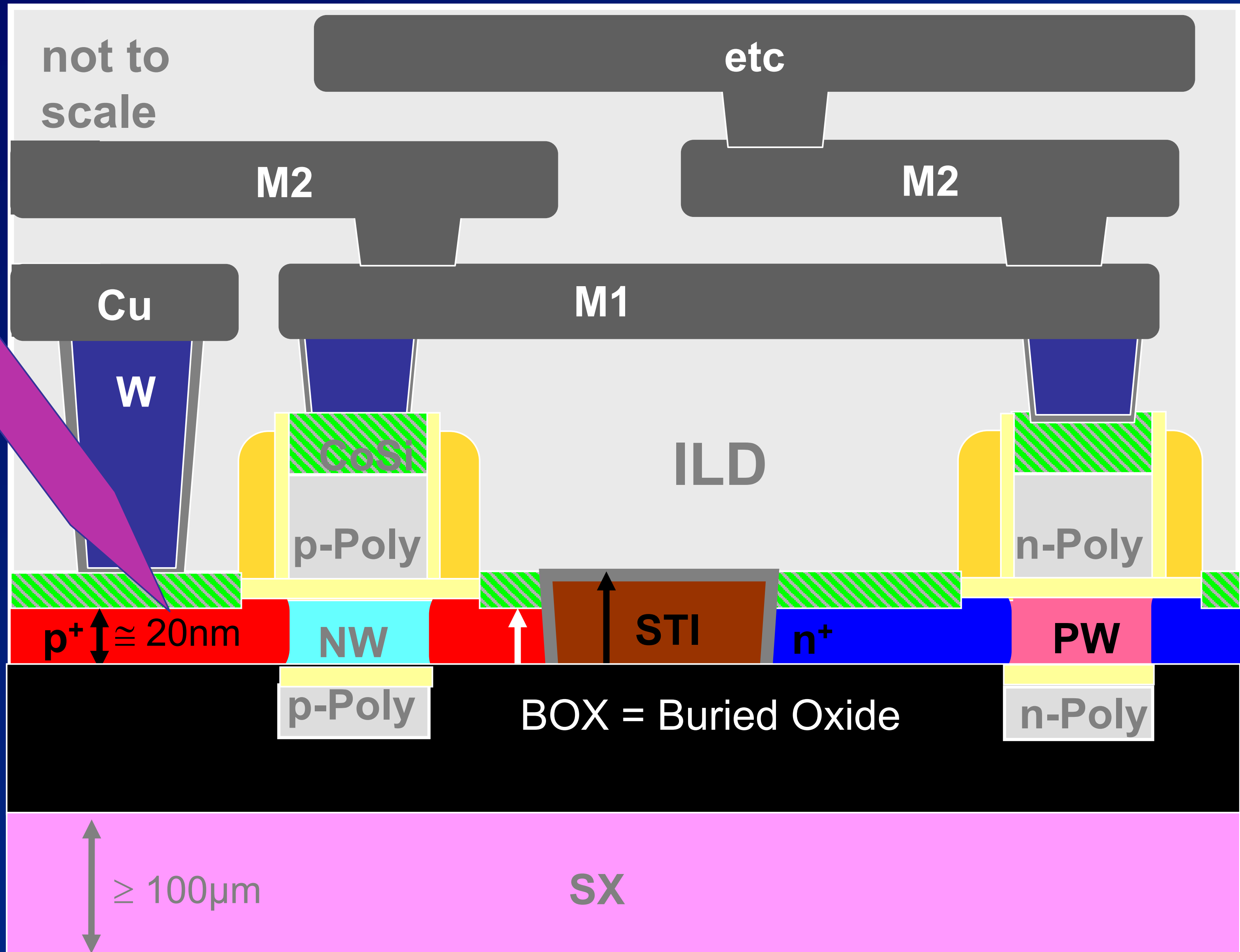
UltraThin Si - Ideal Platform for NanoAnalysis

Ultra Thin Backside Technique	**IR Technique**
Visible or UV Laser Stimulation	LADA, Dyn. LS
Nanoprobing, C-AFM	
E-Beam Techniques:	
- Voltage probing	LVP, TRE
- E Beam induced photocurrent	LADA, Dyn. LS

TUB Research

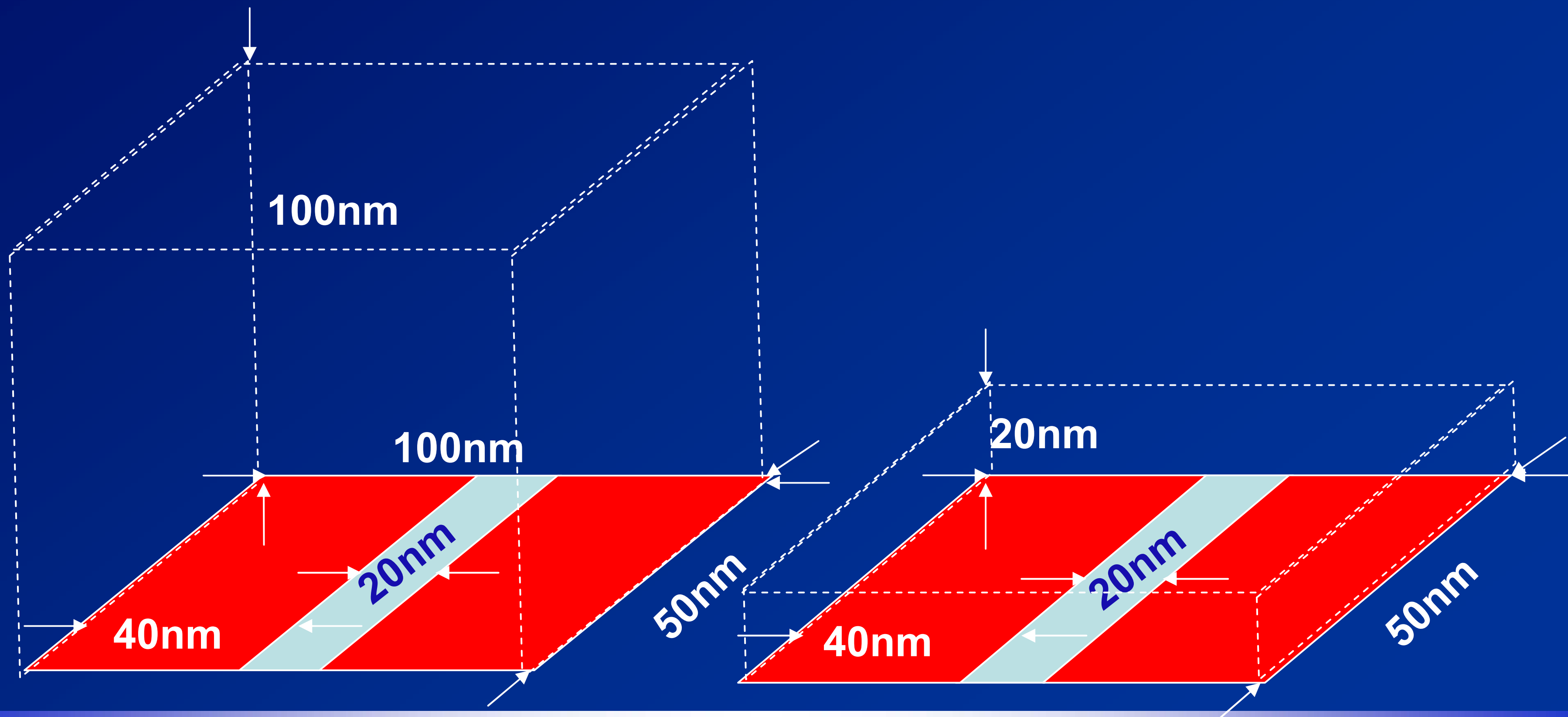


Dual Gates: Ultra Thin Body



Interaction Dimensions

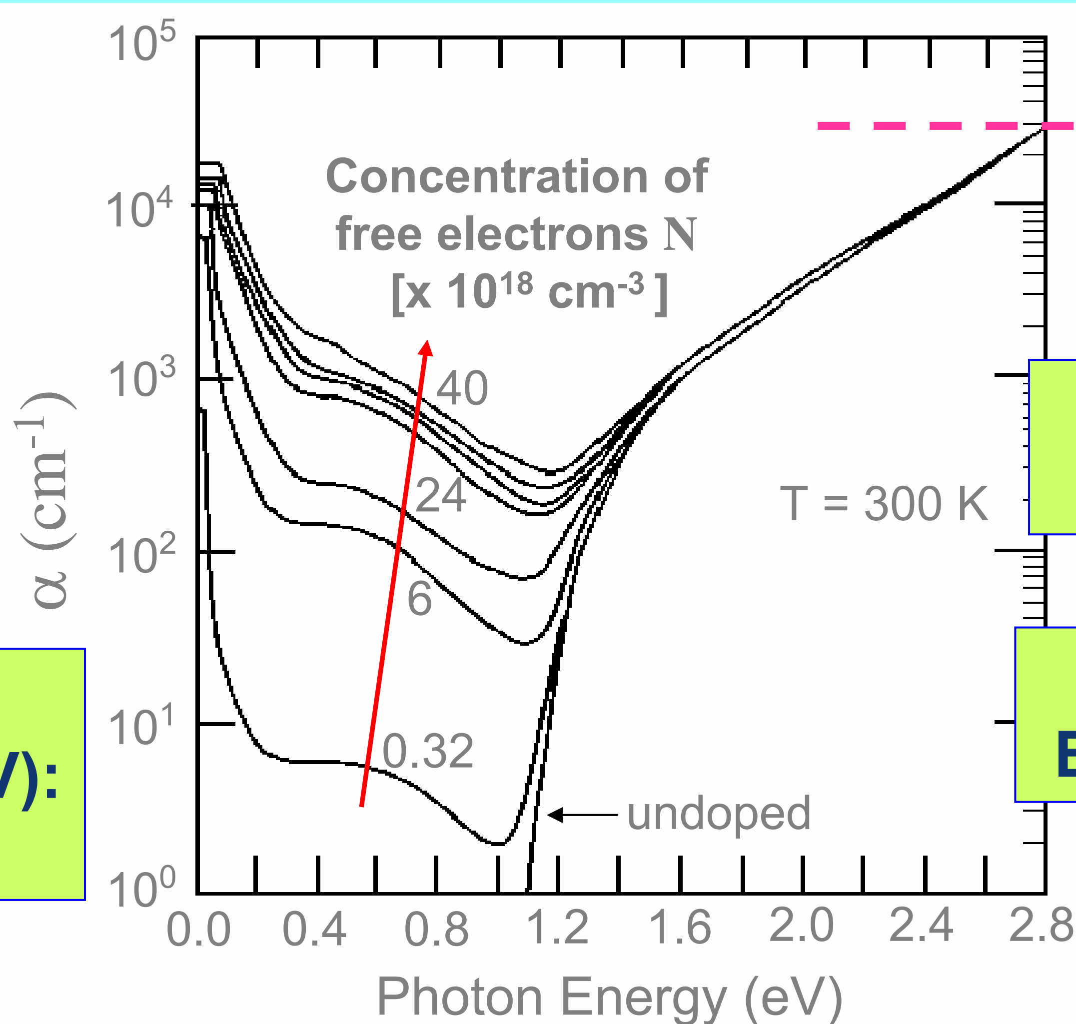
- 20nm Gate length Technology
- UTS (SOI PD)
- UTB (SOI FD / Dual Gate etc)



Backside Access: Transmission of Light in Silicon

Spectral Absorption in Silicon

Soref et al., IEEE J. of Quant. Elec., Vol. QE-23, No.1, January 1987



UTS:
~ 350nm

Blue Light
430nm (2.8 eV):
$\alpha \sim 350nm^{-1}$

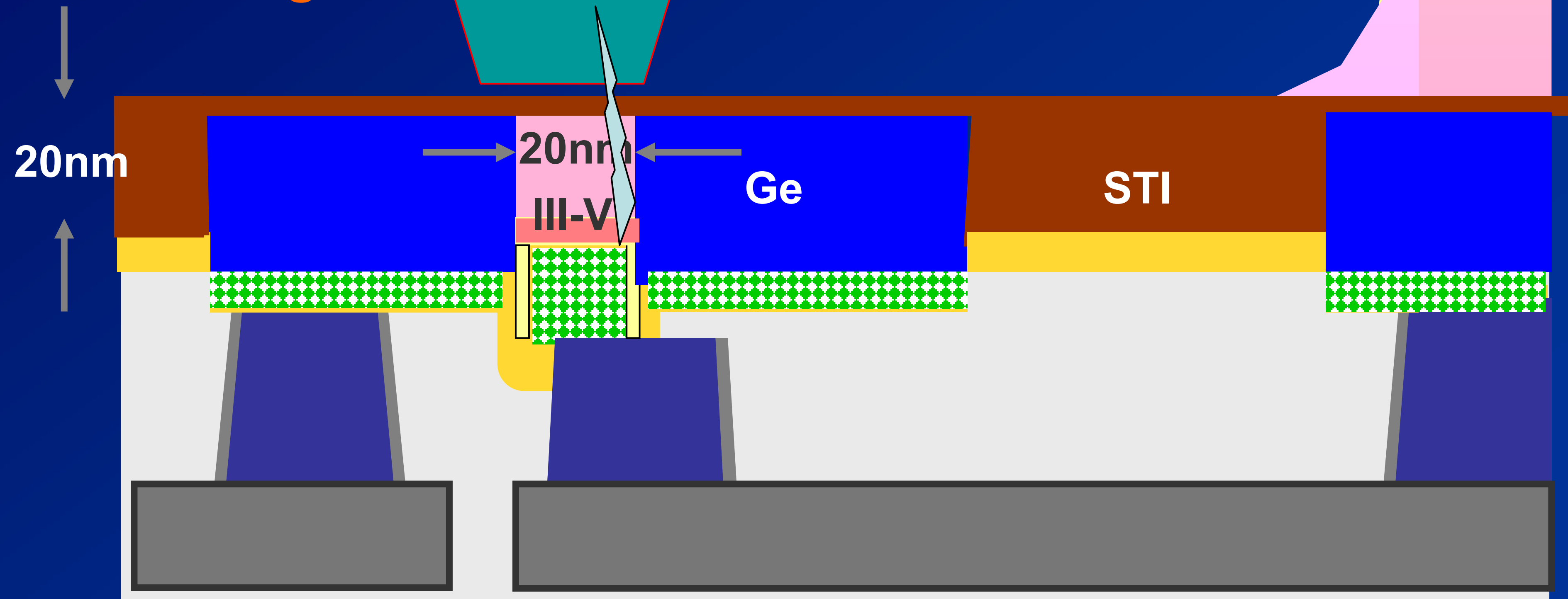
UTB:
20nm

UV?
EBeam?

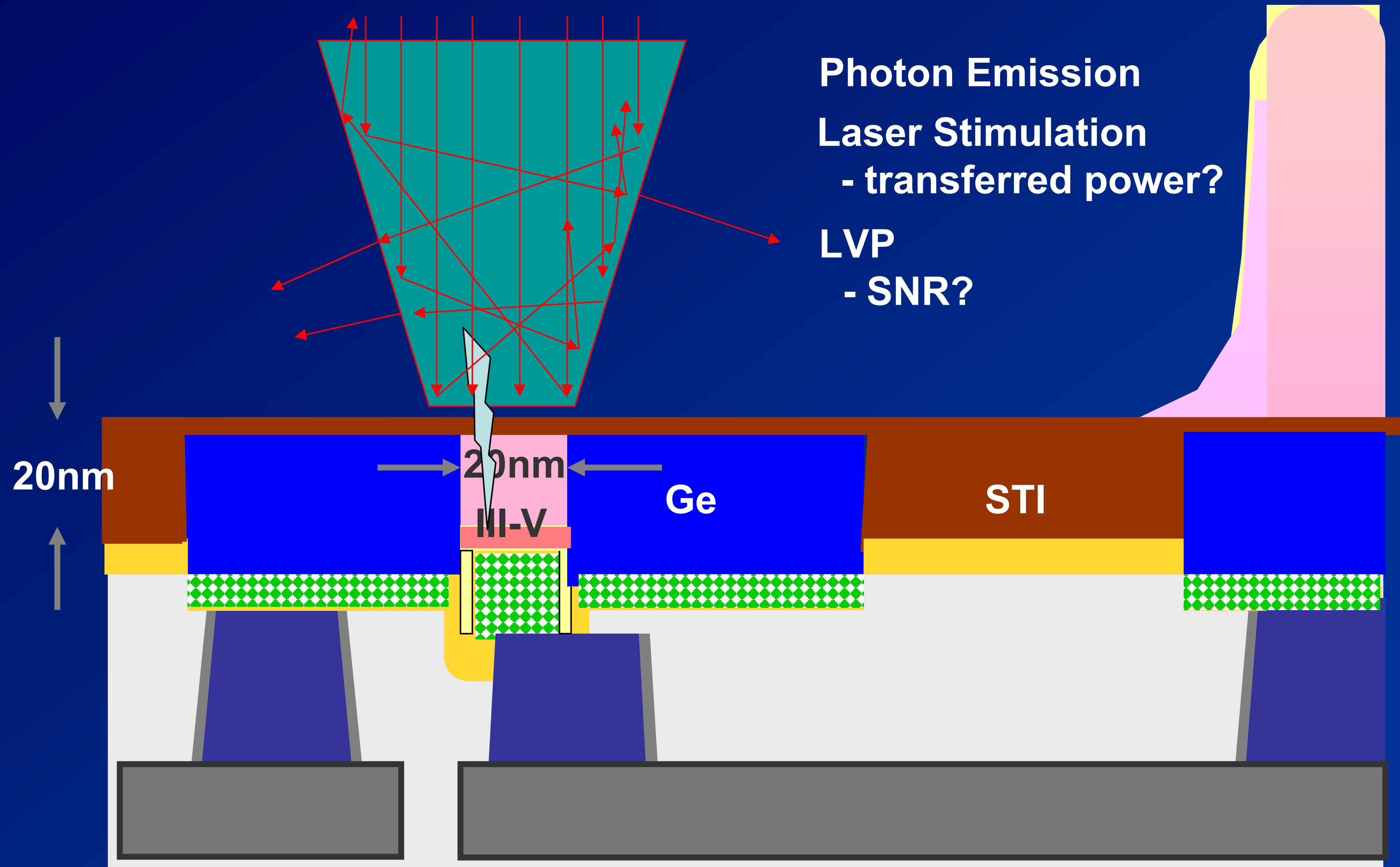
SNOM on UTB

Resolution
= f (tip geometry, working distance)
but independent of wavelength !

Photon Emission

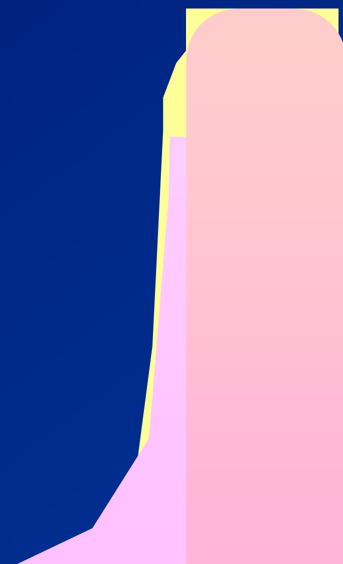


SNOM on UTB



SNOM on UTB

Resolution
= f (tip geometry, working distance)
but independent of wavelength !



20nm

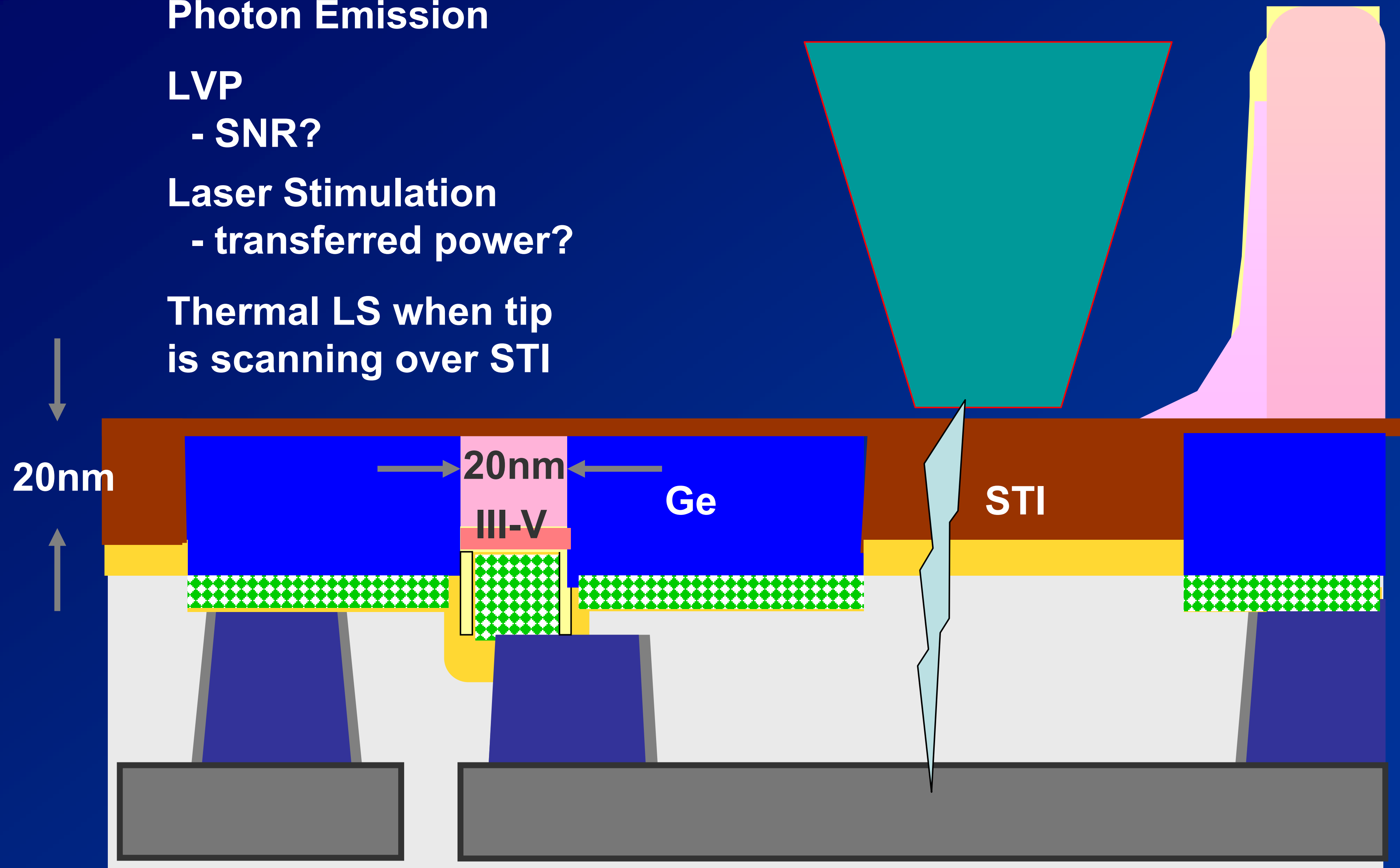
20nm

III-V

Ge

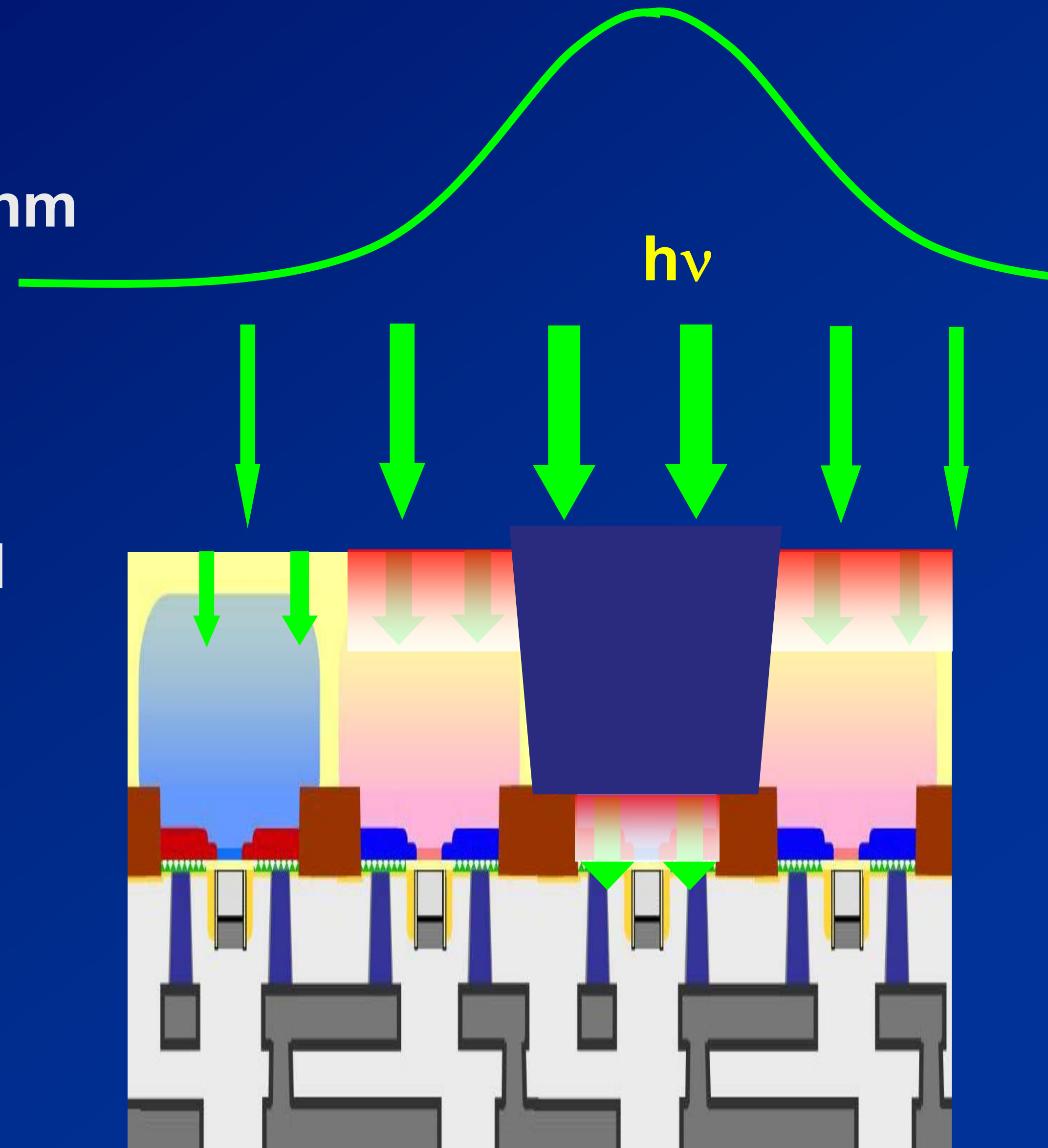
STI

SNOM on UTB

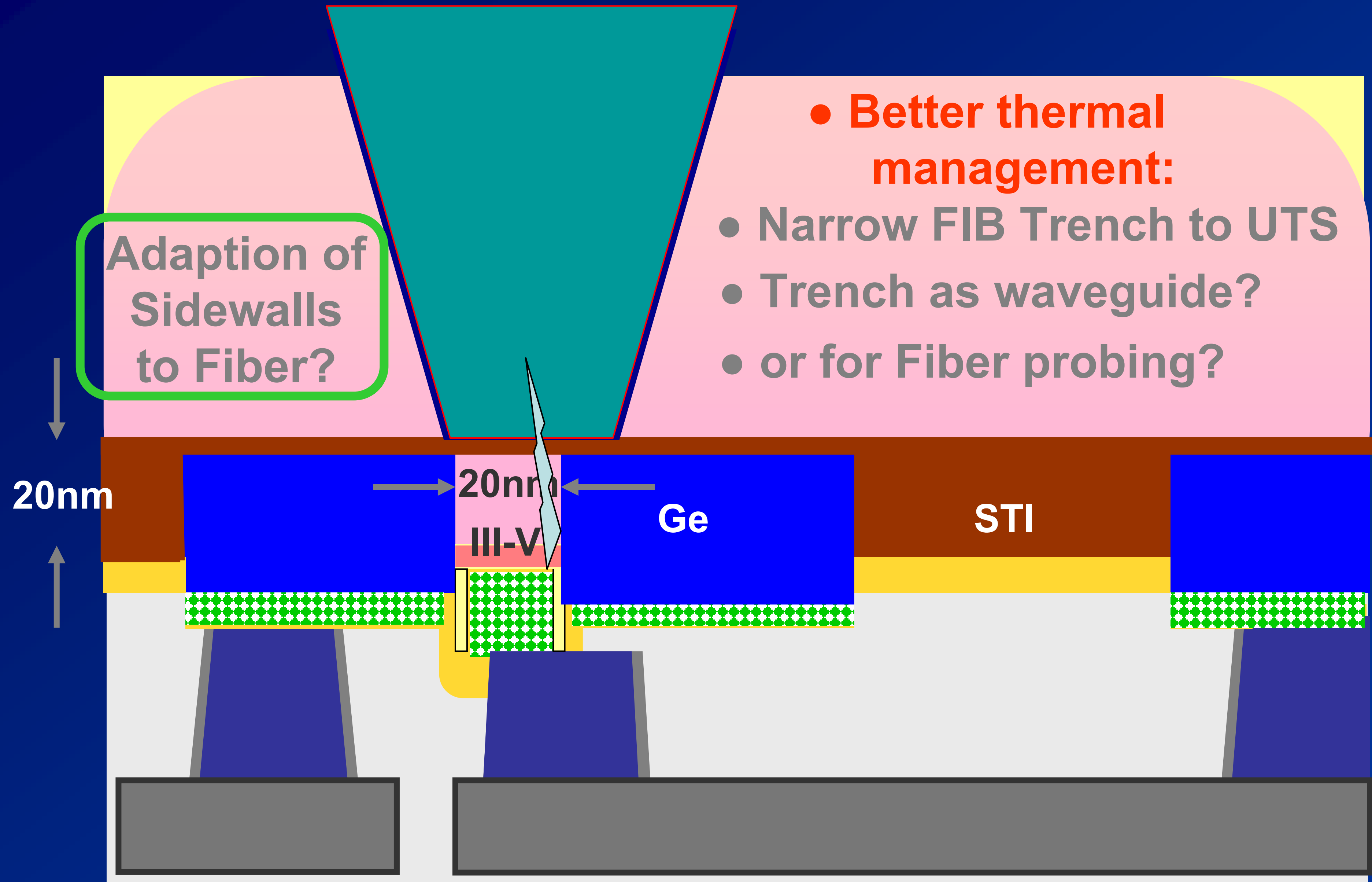


FET Delay Variation on Defined Node

- shorter wave length
- absorption depth ~ 100nm
- optical confinement by FIB trench - waveguide -
- impact only on exposed transistor
- Resolution of stimulation by confinement

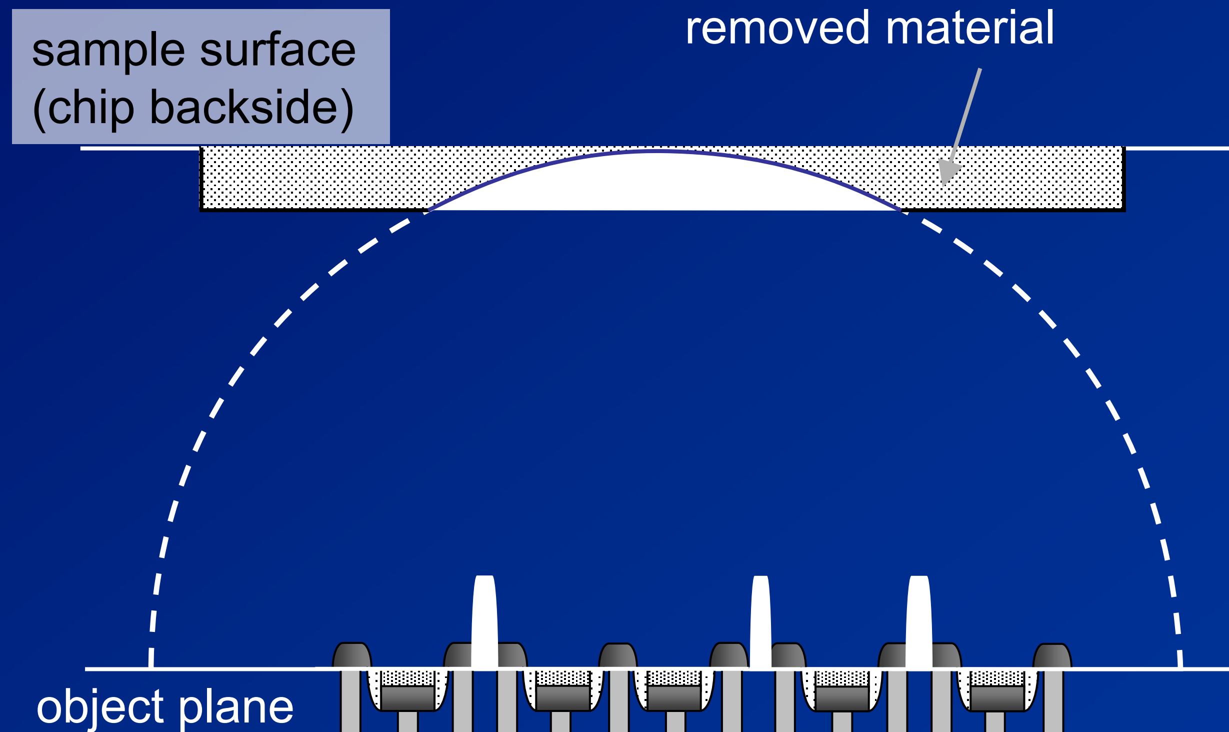


FIB Guided SNOM on UTB



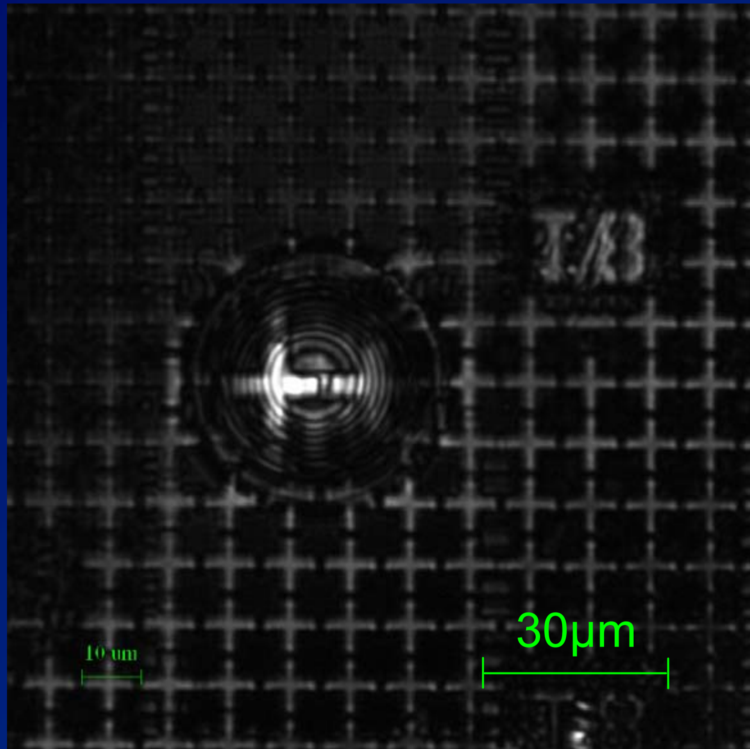
FIBbed SIL

Solid Immersion Lens (SIL)
created out of the bulk silicon material
→ perpendicular transition Si / air, no refraction

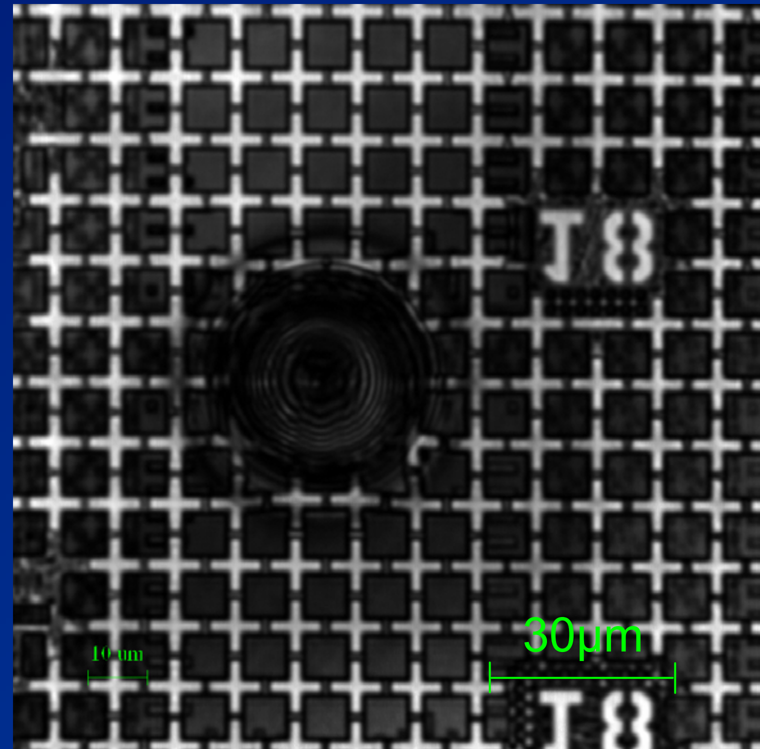


Results

Images of the SIL ($r \approx 91$ µm, $t \approx 34$ µm) using a laser scanning microscope at wavelength $\lambda = 1064$ nm



focused on SIL



focused on background

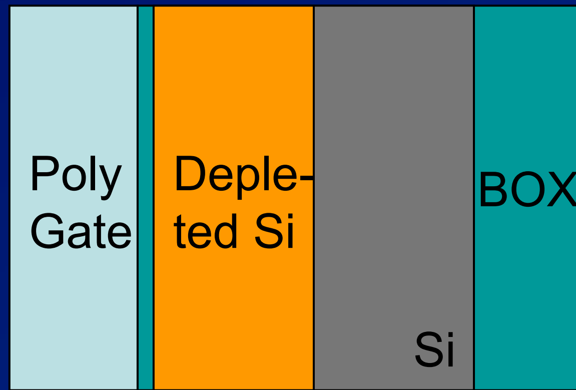
Nanoscale Potential

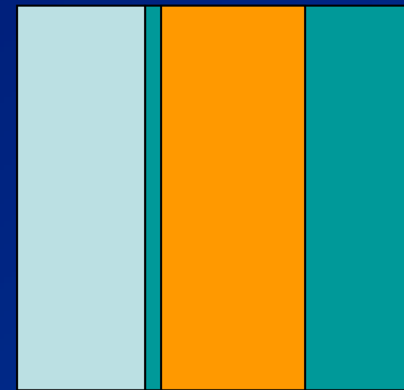
Technique	Resolution	Potential	Comment
Optical through bulk Si (IR)	500nm	100nm (SIL)	Limited resolution
Nanoprobing	50nm	10nm	Limited dynamics
E Beam	100nm	20nm	Material degradation?
Optical through ultra thin Silicon	300nm	< 100nm (SIL)	Realization complex
UV through ultra thin silicon	150nm	< 50nm	Material degradation?

Ultra Thin Body UTB

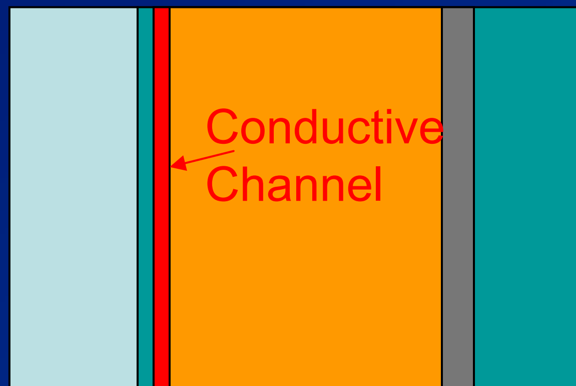
SOI: Partially depleted = PD | Fully Depleted FD

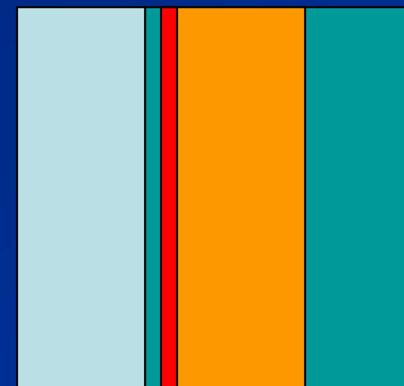
$V_{GS} = 0$





$|V_{GS}| > |V_T|$





Subthreshold Slope ≅ 60mV / dec

FD active layer ~ 20nm => UTB