Static Photon Emission

Background

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Photon Emission: Fundamentals

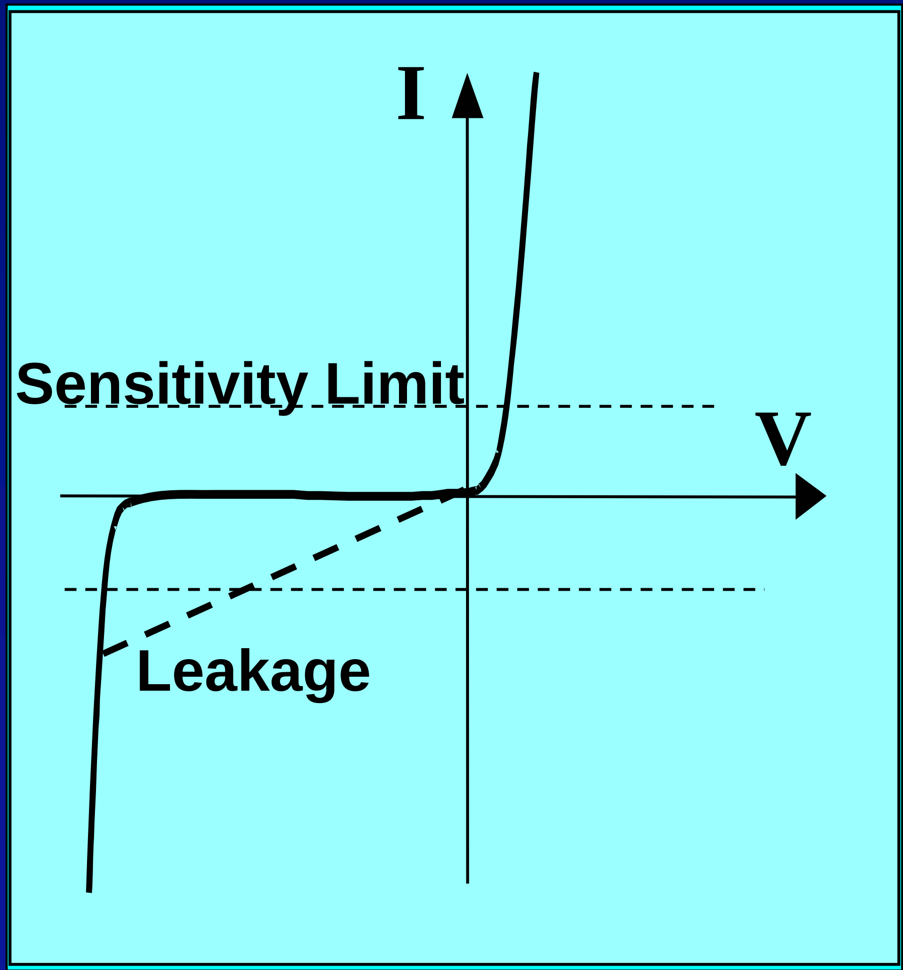
The two Basic Mechanisms of Photon Emission in Si

Example:
P/N Junction:

Reverse Bias

1) Intraband:

Carriers pick up kinetic energy in E-field and relax by emitting photons

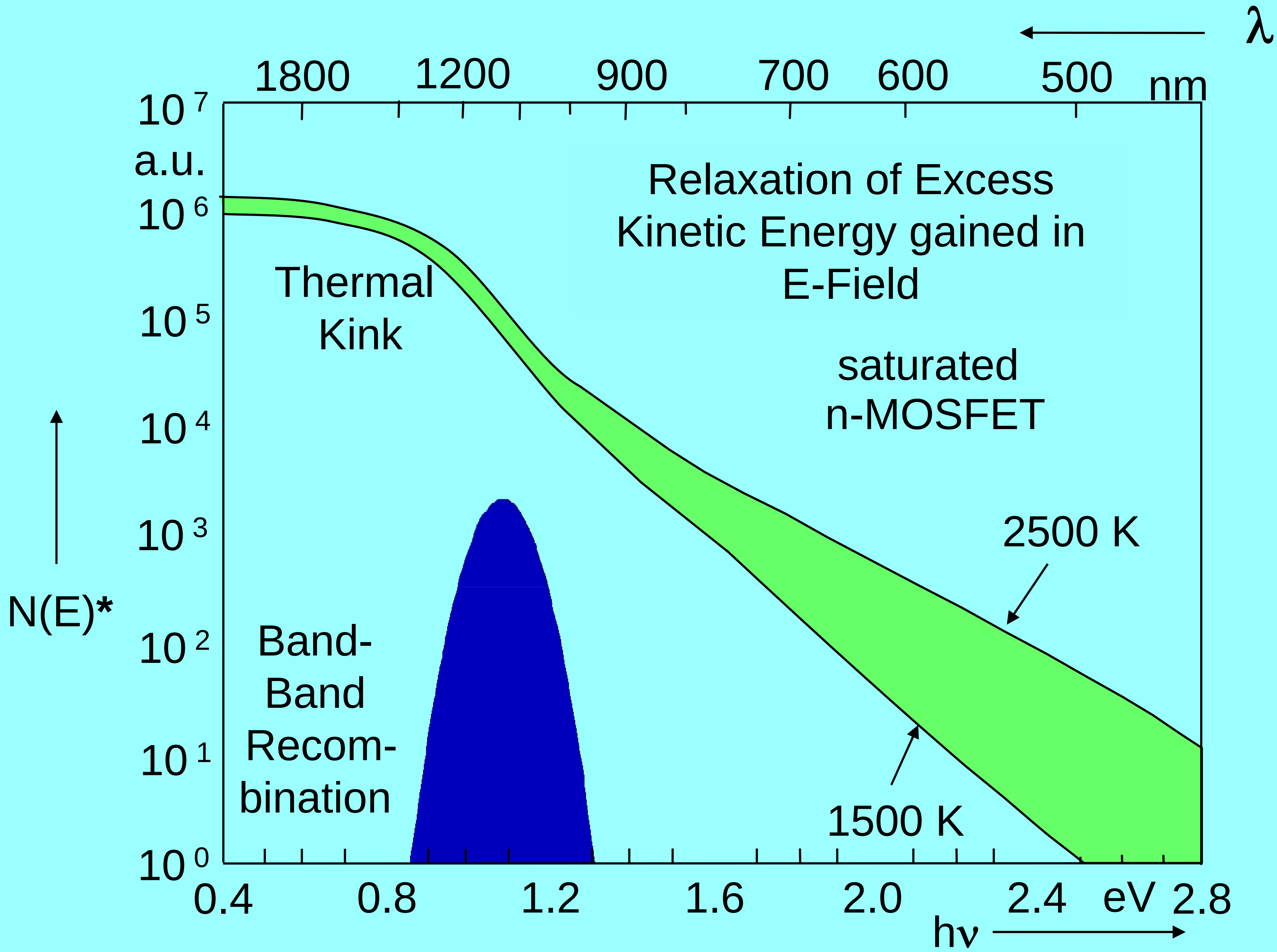


Forward Bias

2) Interband:

Band-band recombination of injected excess carriers

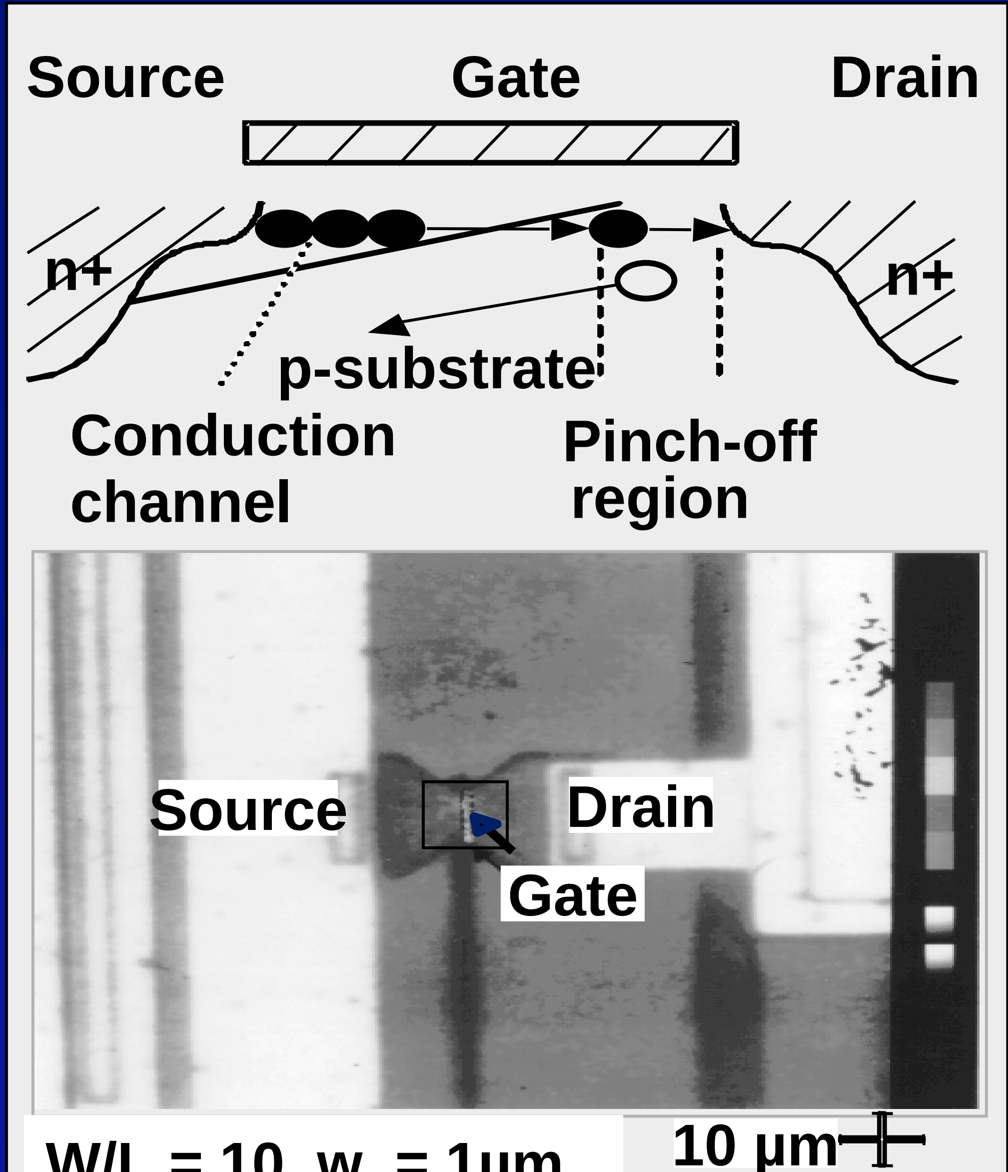
Photon Emission Fundamentals: Spectra



* N(E) : relative Number of Emission Events

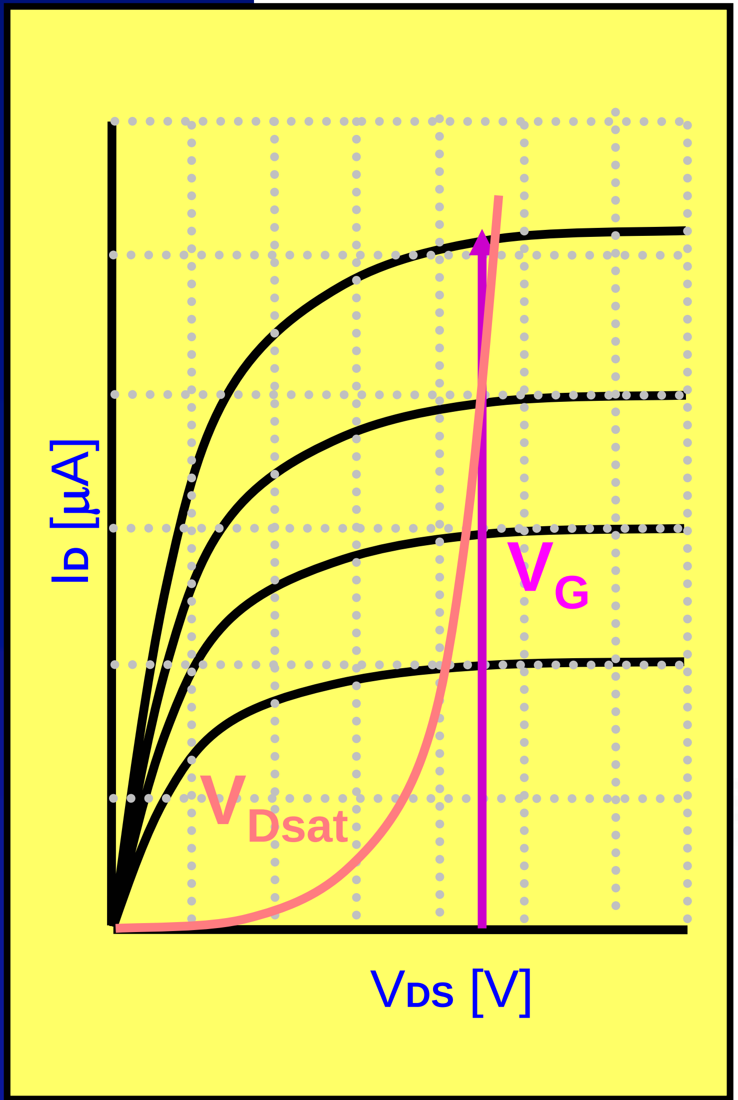
Photon Emission from MOS FET

Saturation



W/L = 10 w = 1µm
V_D = 6V, V_G = 3 V

MOS: Saturation and Substrate Current



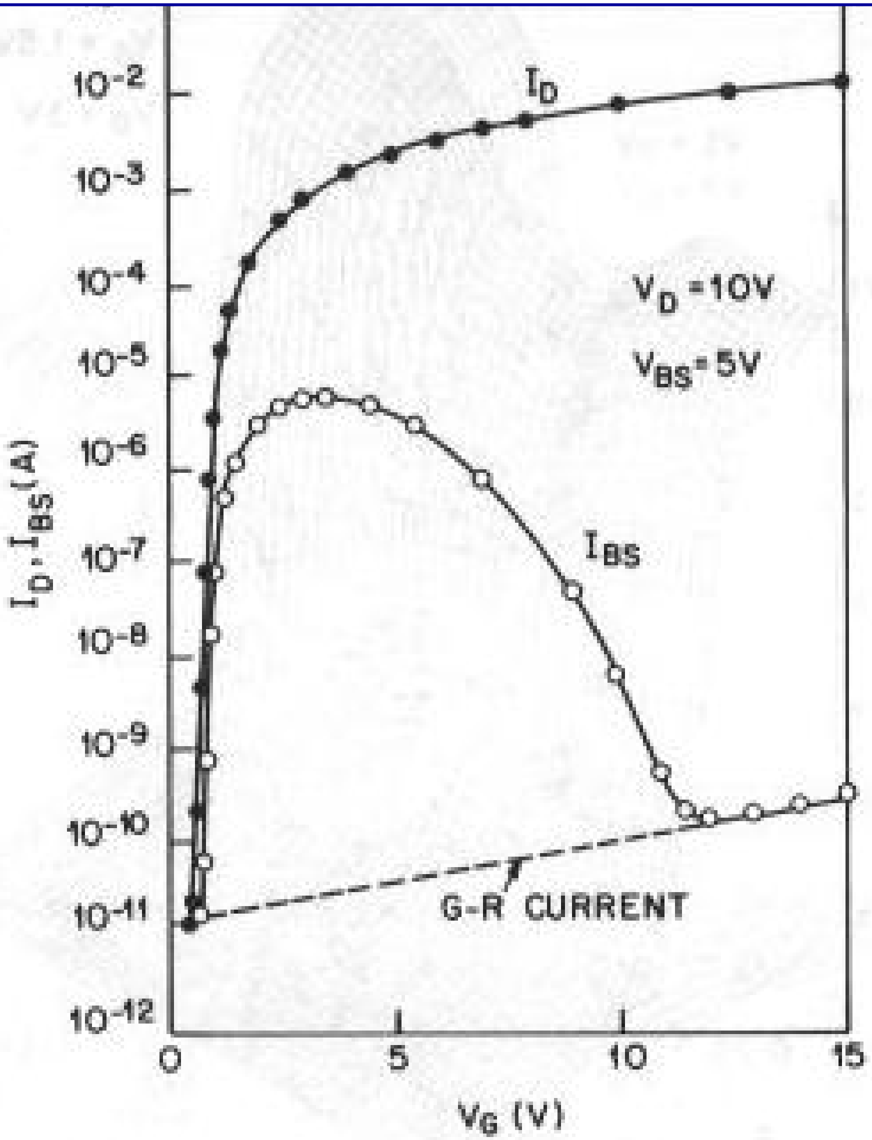
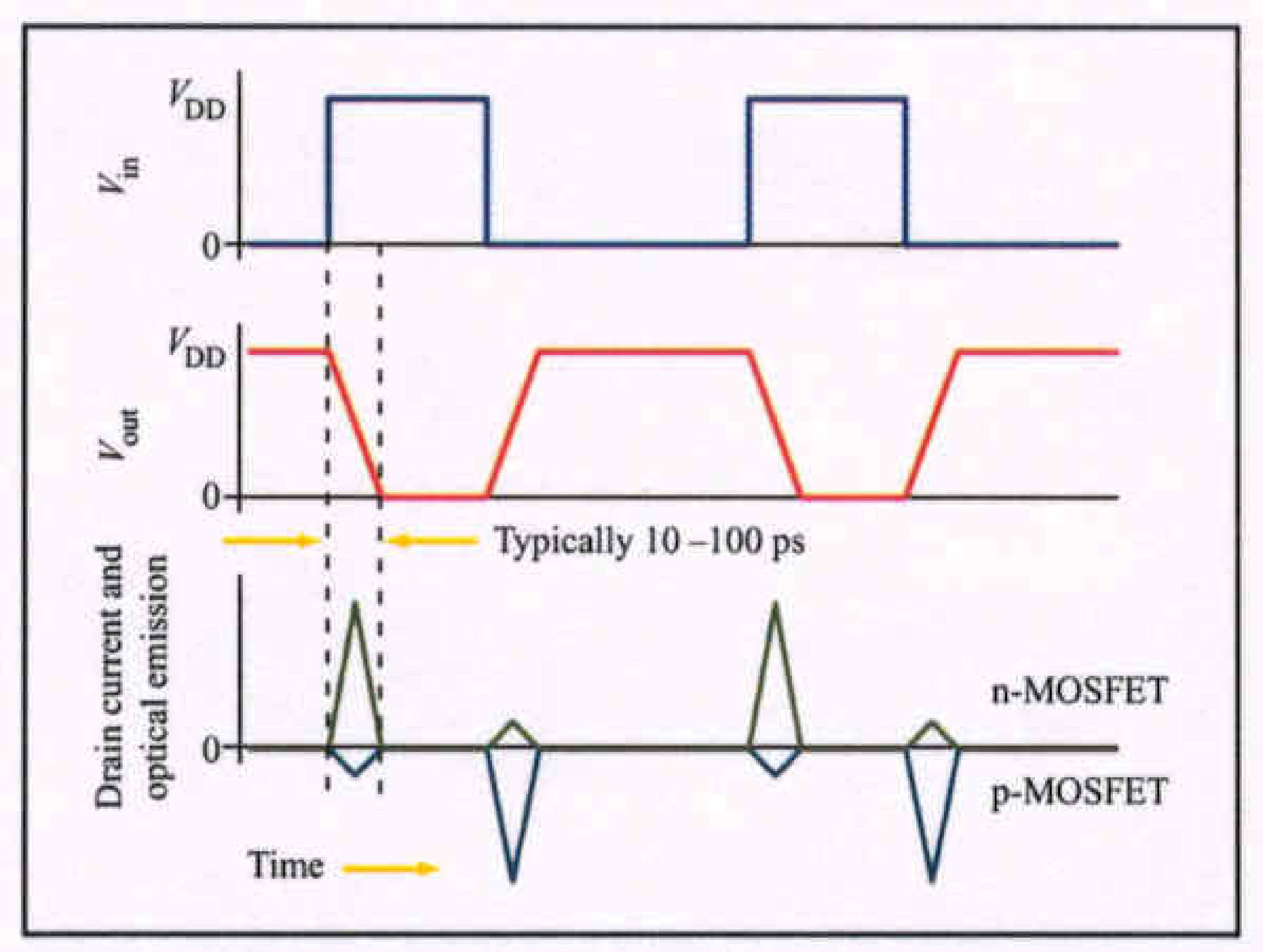


Fig. 46 Drain current and substrate current versus gate voltage of a long-channel MOSFET. (After Kamata, Tanabashi, and Kobayashi, Ref. 49.)

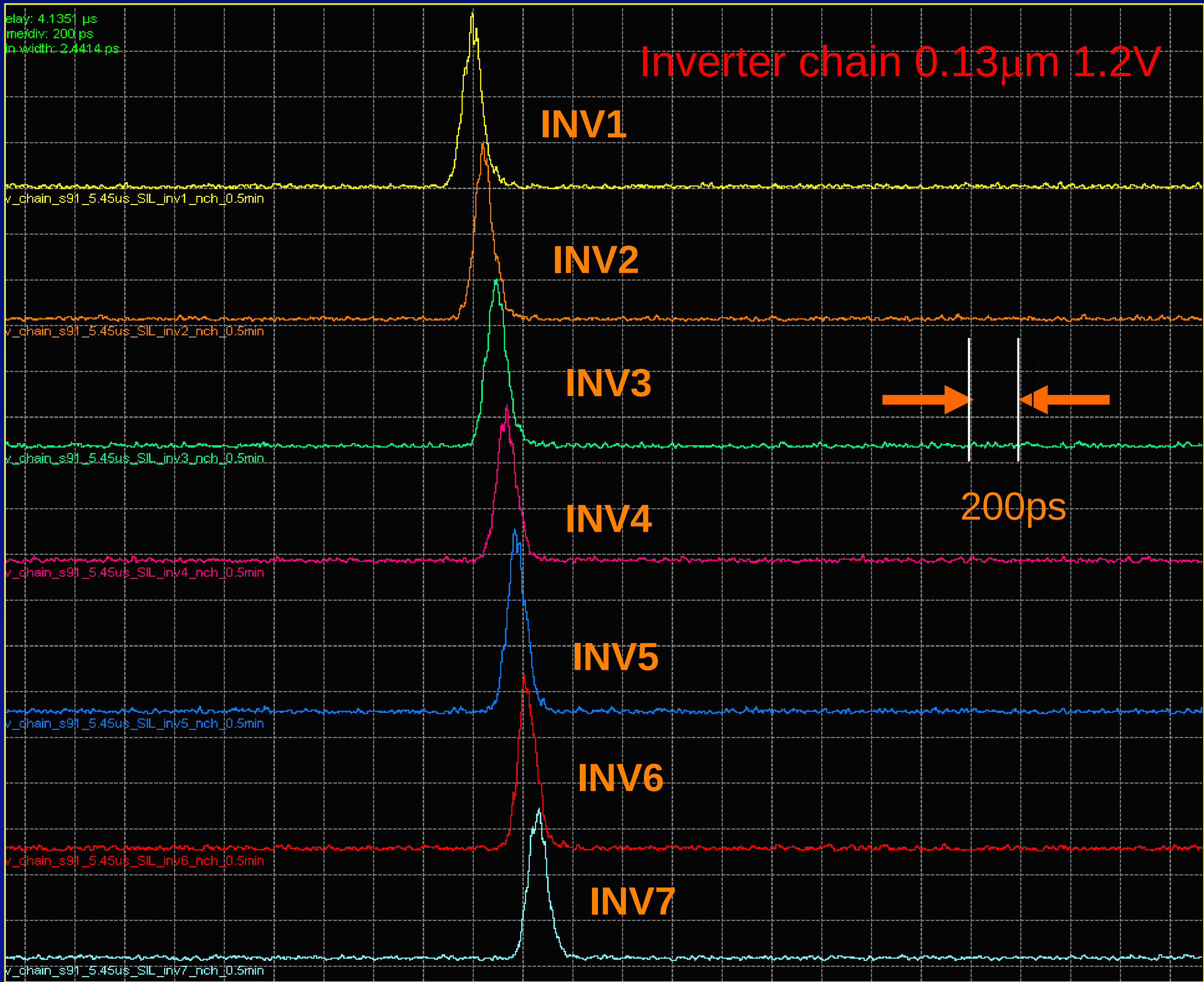
Sze, Semiconductor Devices

Time Resolved Emission TRE



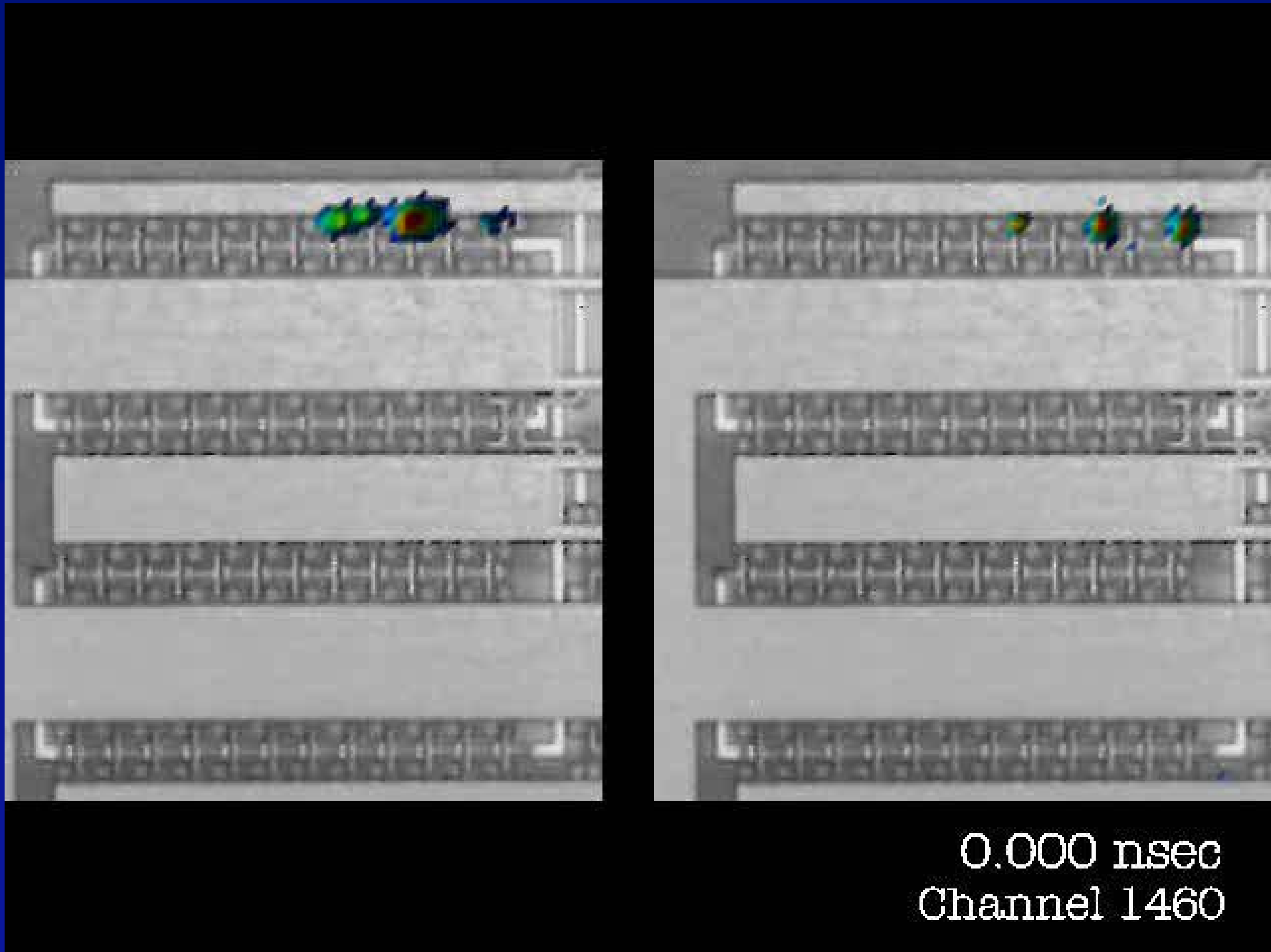
ref
J.C.
Tsng
IBM

Example: Propagation Delay



Ref: Credence

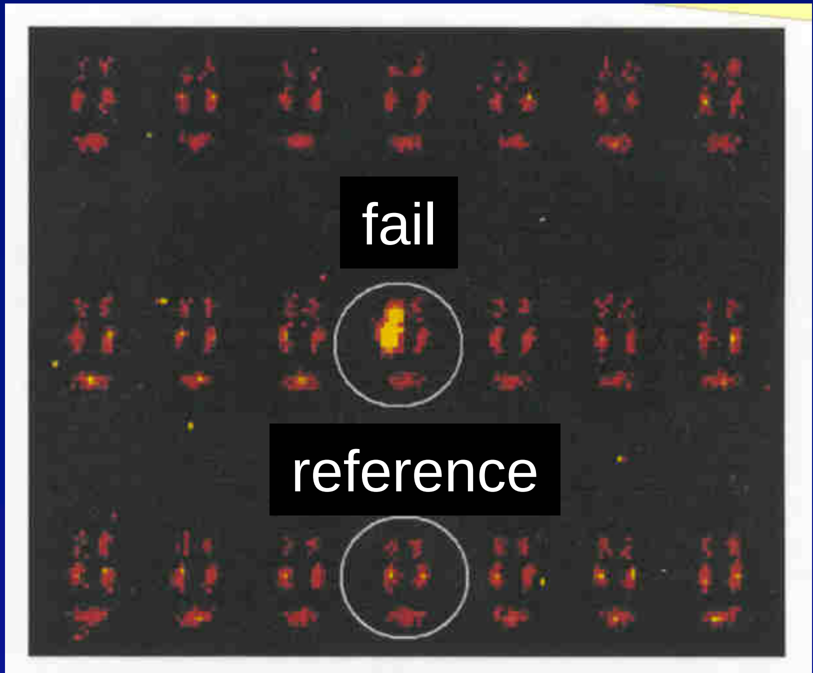
TRE in Ring Oscillator - Demonstrator



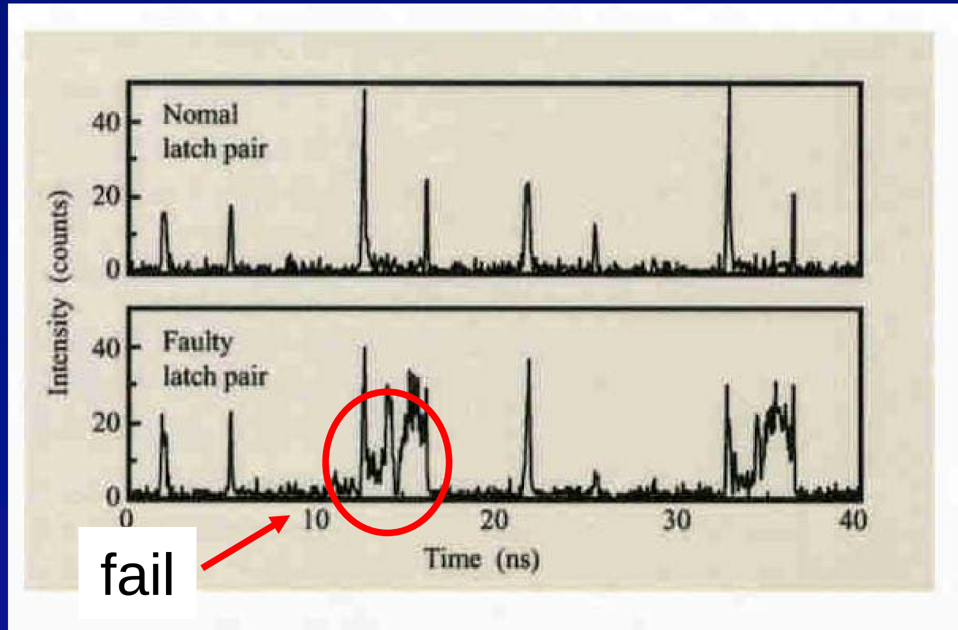
Coutesy IBM / Richard Ross

Static Photoemission of Dynamic Signal

example design analysis:



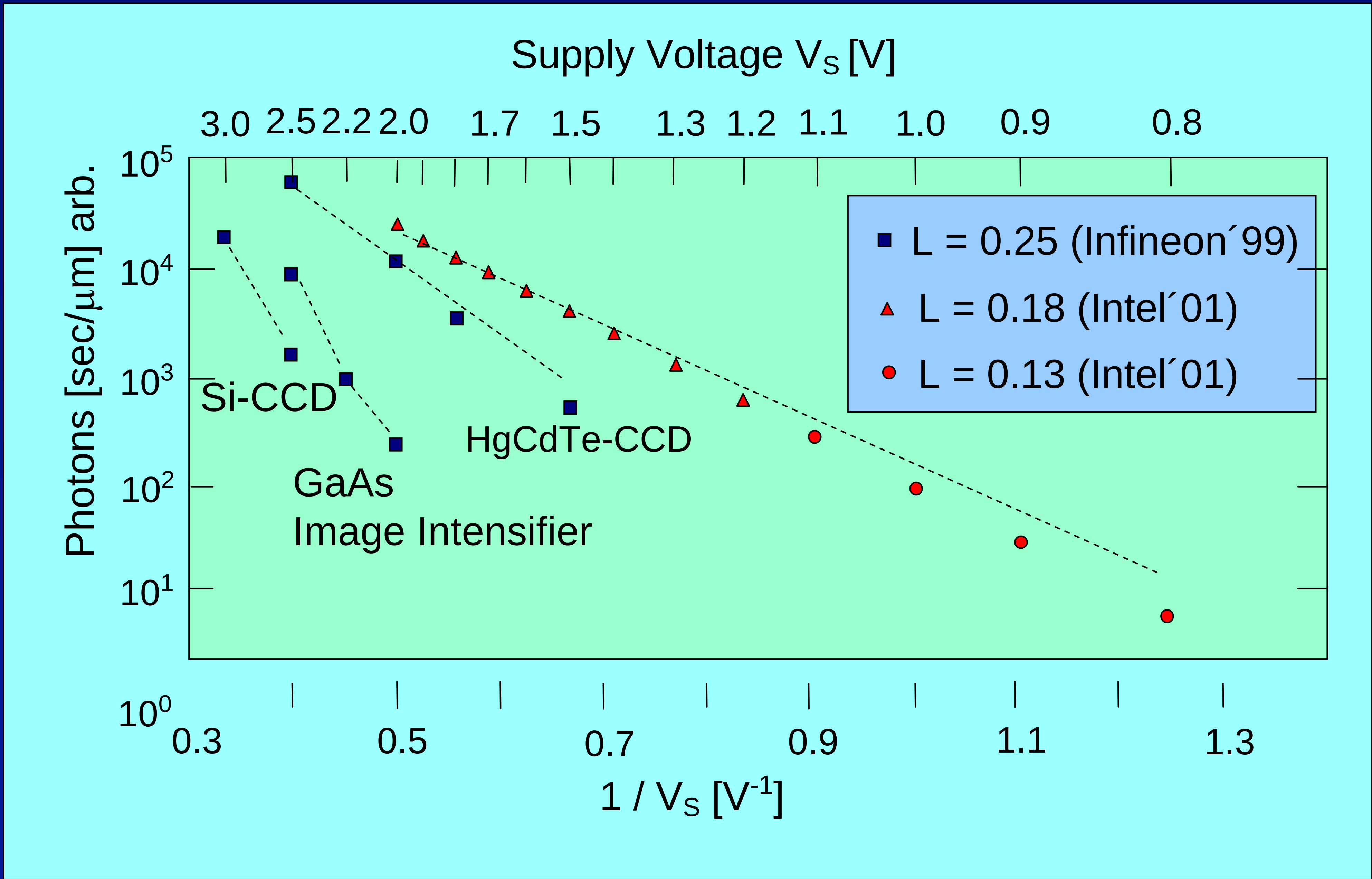
Time integrated image of light from a register file while running a test pattern producing a fail



‚optical waveform‘ from normal and faulty latch pair

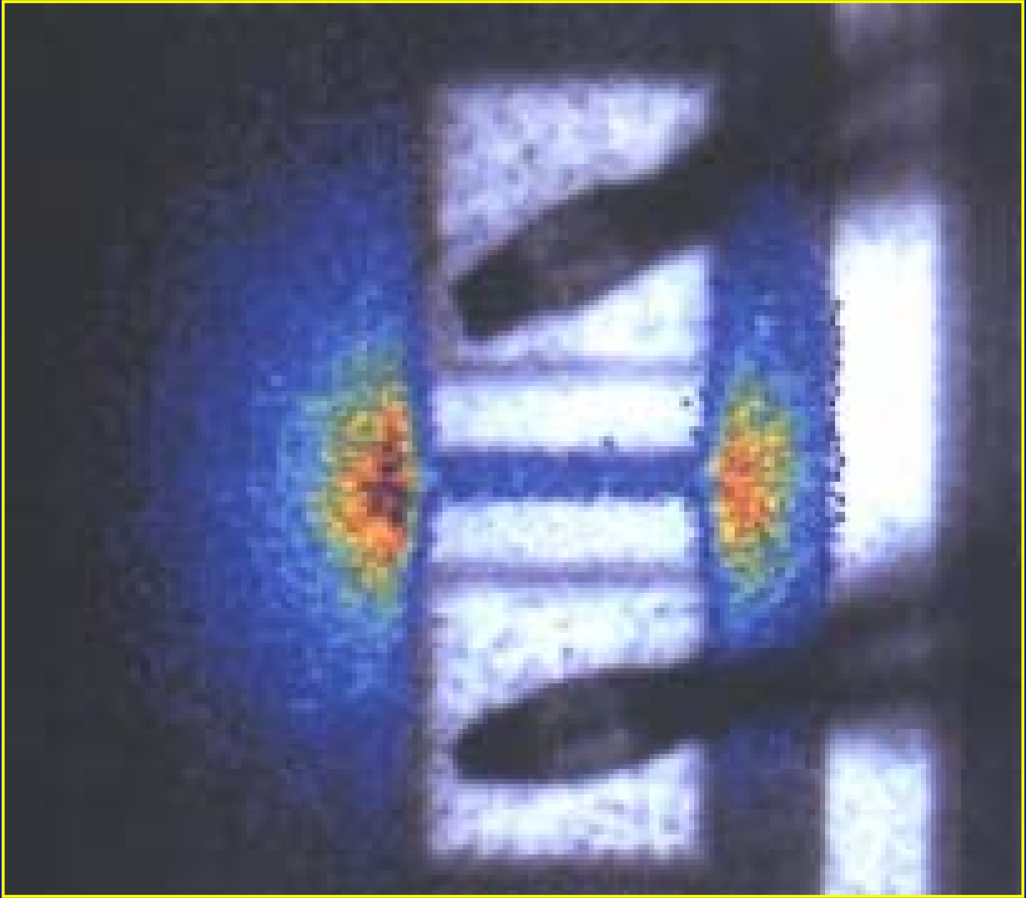
Ref J.C. Tsng, IBM

Static emission



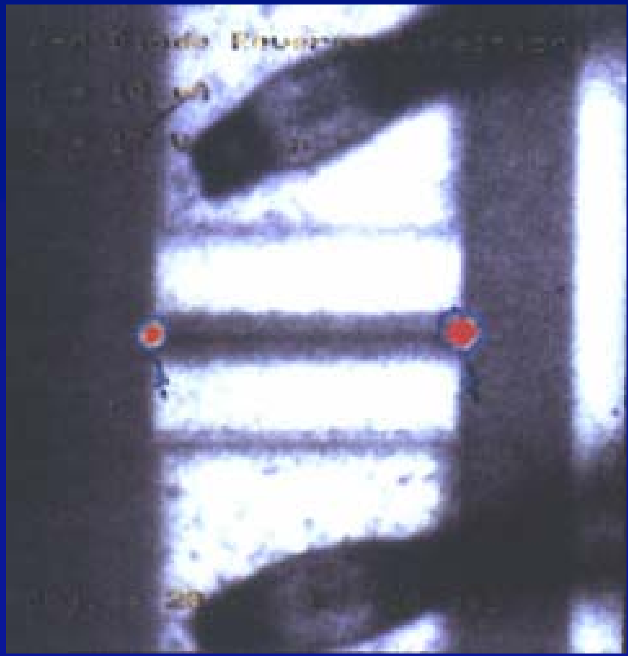
Bipolar Diode

Forward Bias 100µA



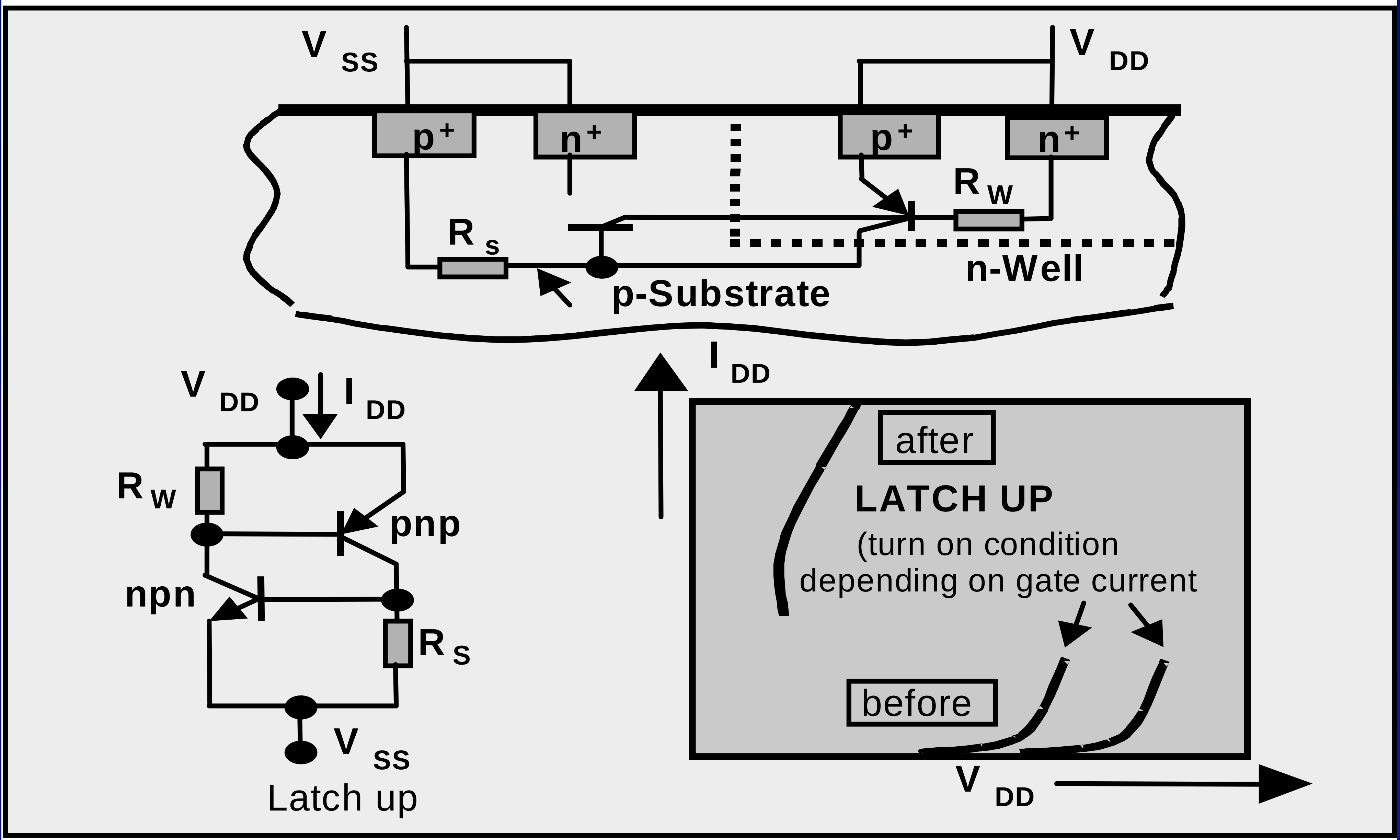
Reverse Bias 10 µA

Sensitivity limit: 10nA



PE-Classification of Emission Sources

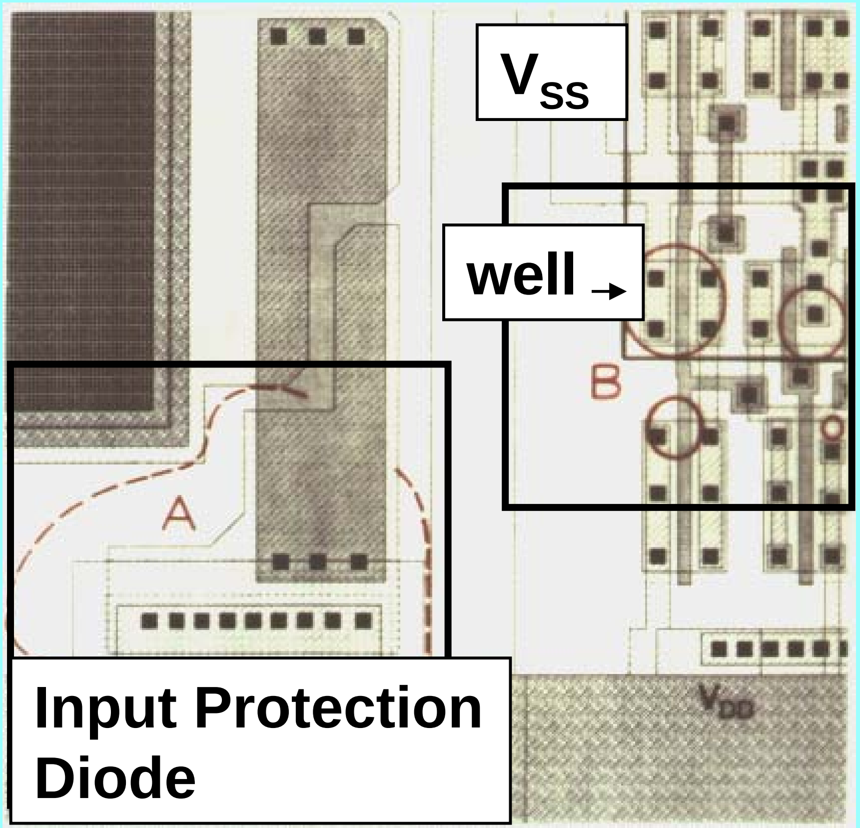
Latch up



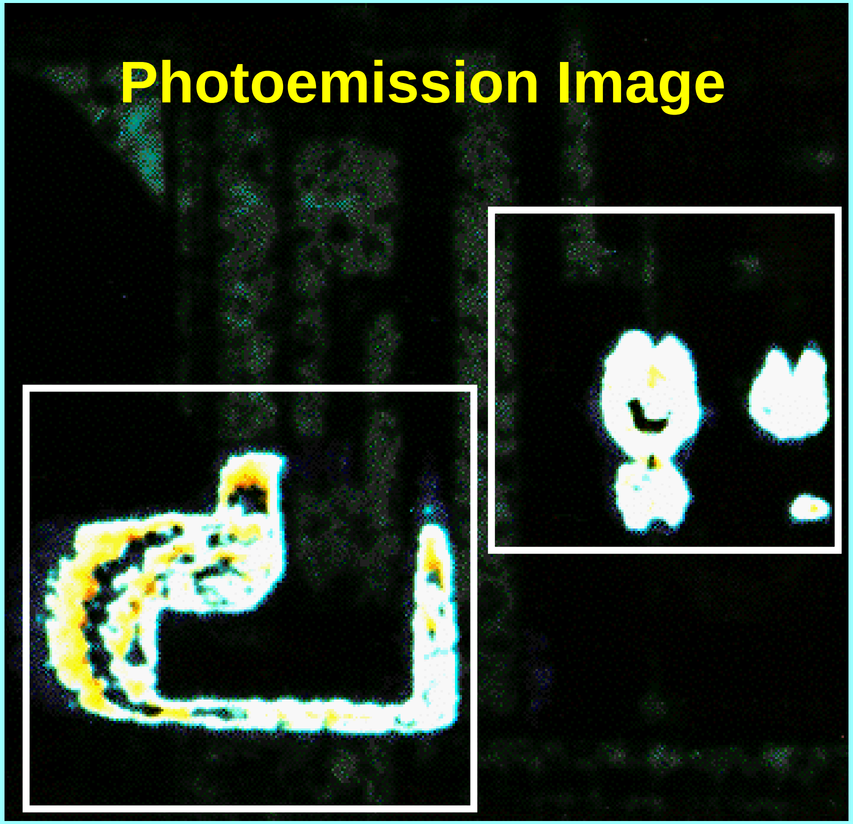
PE-Classification of Emission Sources

CMOS Latch-up

<u>Latch-up operation:</u> A: input protection diode
B: latch-up area



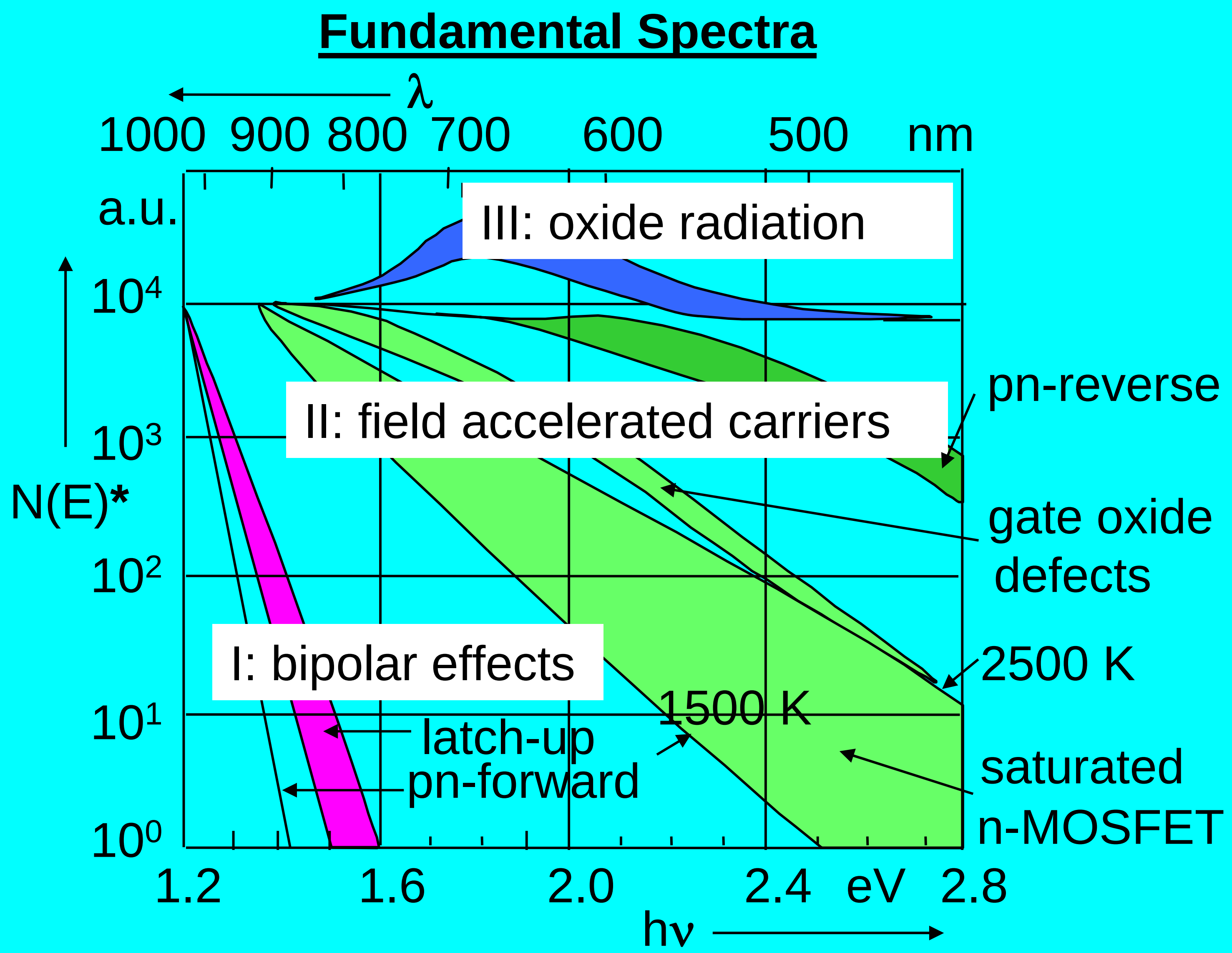
Layout



Superimposed emission

20µm

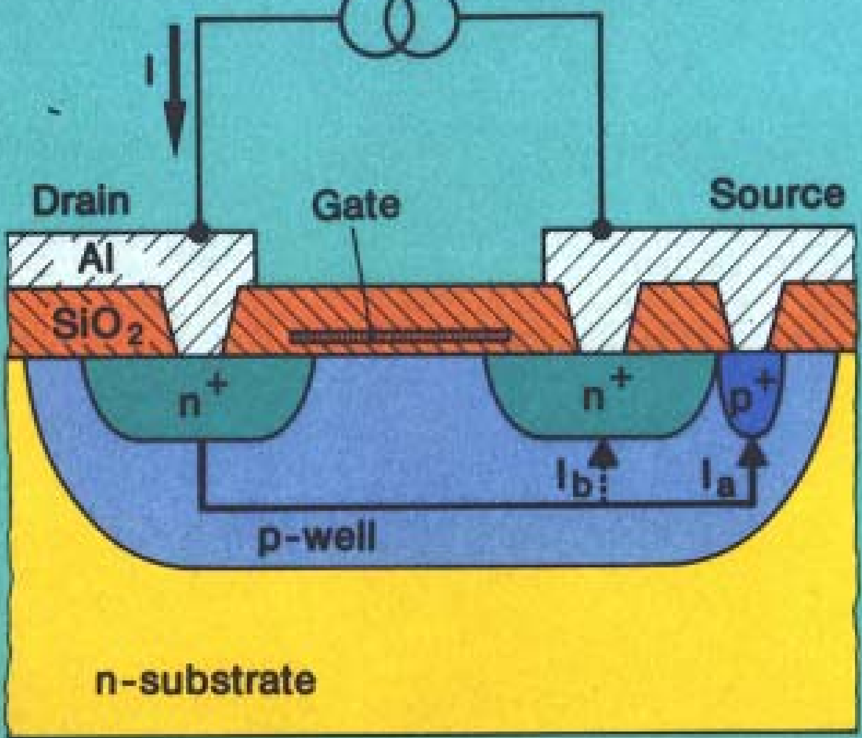
PE-Classification of Emission Sources



* N(E) : relative Number of Emission Events

ESD-protection structures:
Characterization of different operation conditions

Cross-section A – B of the n-channel type (npn)

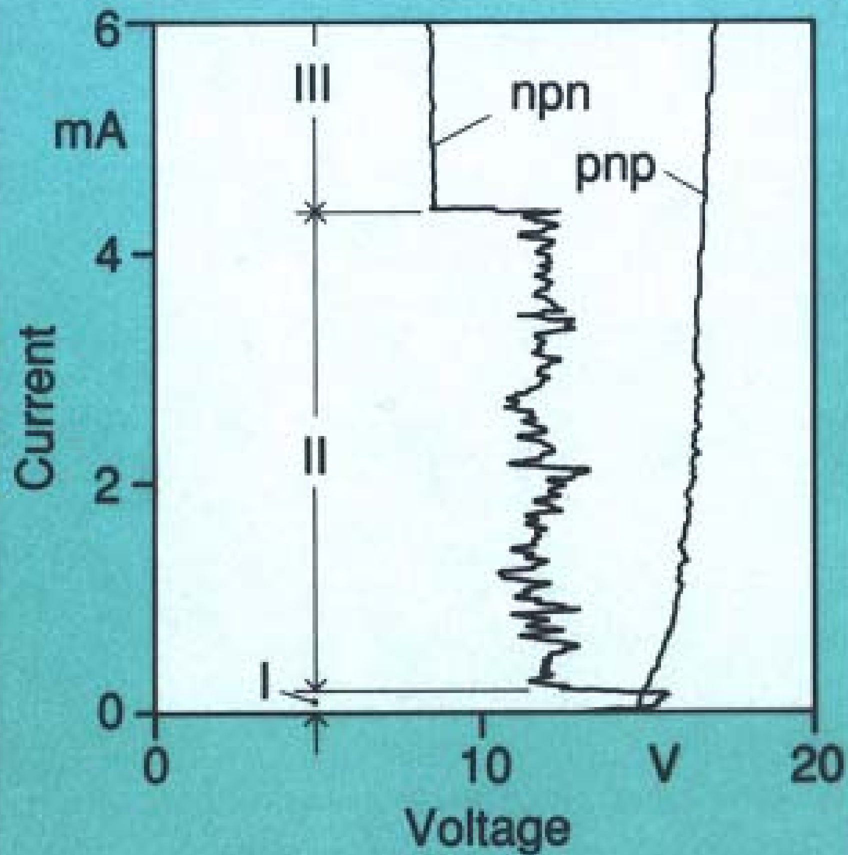


I: total current

I_a: leakage current of the reverse biased pn-junction

I_b: source injection current

V,I characteristic of the npn and pnp devices

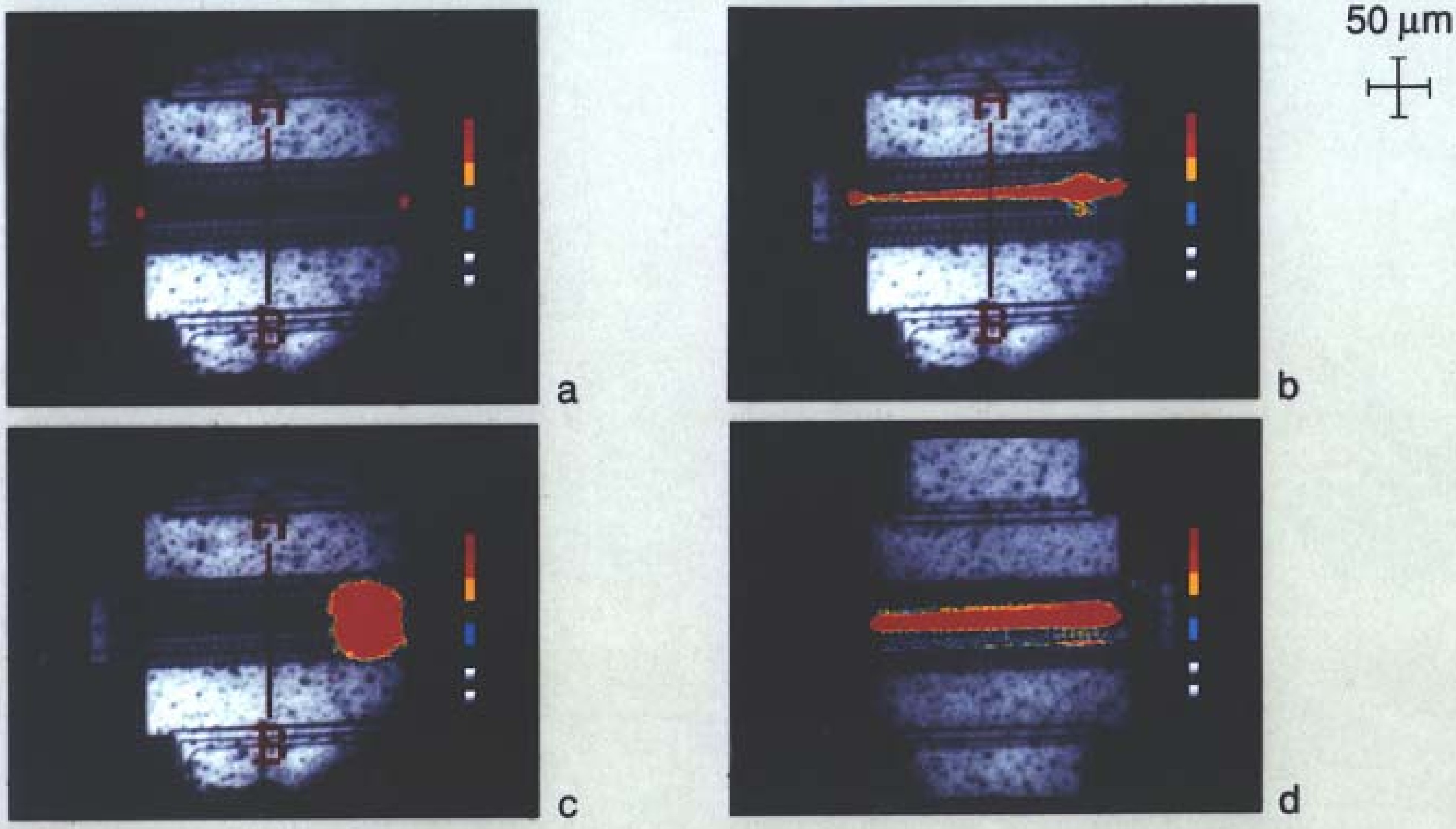


I: low reverse currents (avalanche)

II: snapback operation

III: snapback steady state

ESD-protection structures: Characterization of different operation conditions

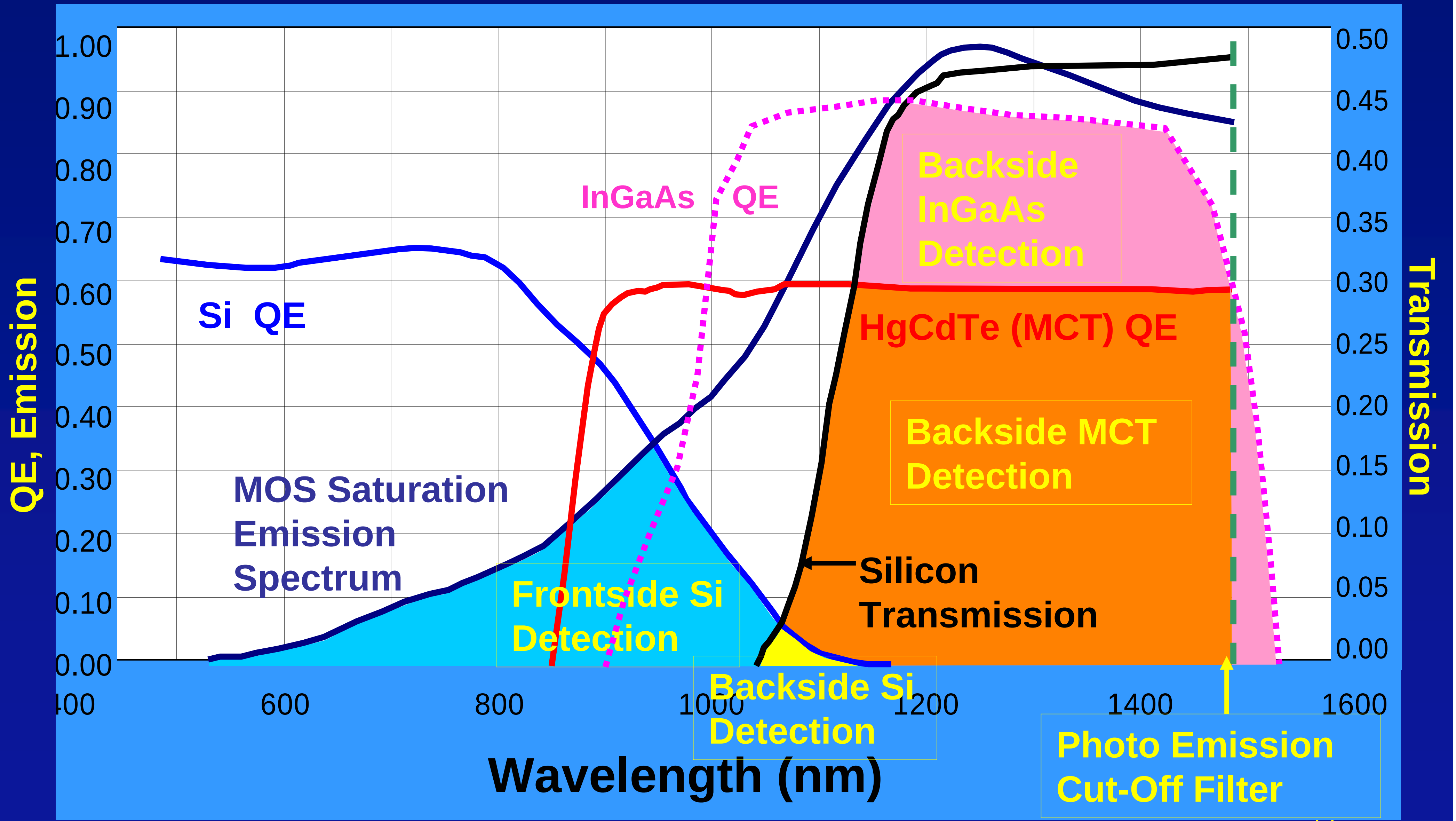


npn-structure: a) domain I (50 µA), b) domain II (2mA), c) domain III (5 mA)

pnp-structure: d) same emission characteristic for all currents (here: 2 mA)

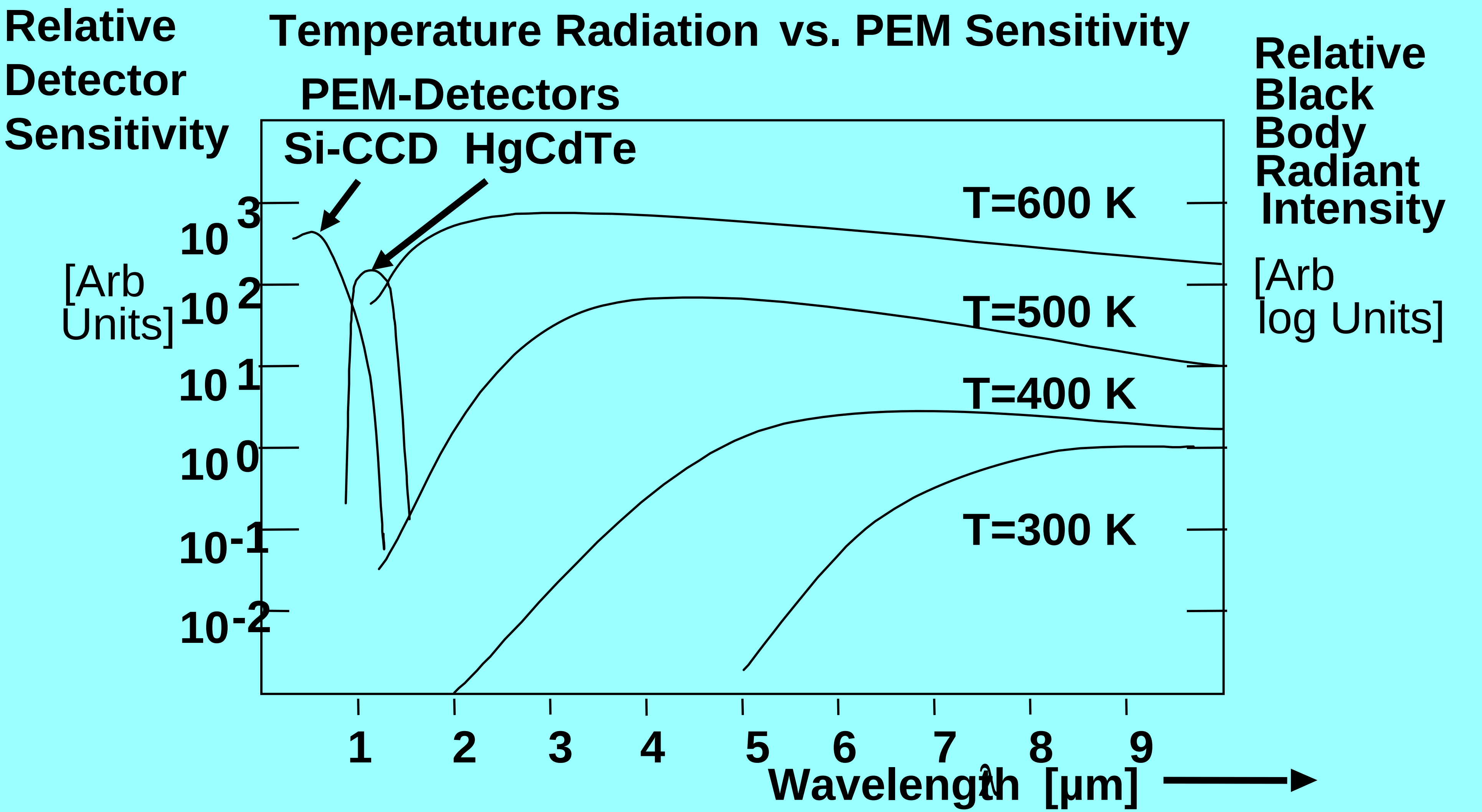
Photon Emission Detection Evolution

Si CCD vs HgCdTe (MCT) vs InGaAs



Ref: Credence

PEM-Equipment and Application



Qualitative Spectral Range Comparison of Black Body and PEM detectors

Conclusion

Photon Emission is the most powerful technique for localization of electrical function and failures in seminconductor devices, frontside and backside