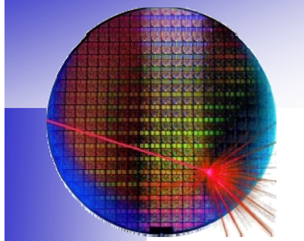

Picosecond Laser Stimulation status, applications & challenges

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Sciences Technologies

Outline

- Picosecond laser stimulation
  - Principles of laser stimulation
  - Specifics of pulsed laser stimulation
    - Energy vs power
    - Charge collection dynamics
    - Impact on resolution
  - Applications

- Results
  - PULS, TRLS, Fault injection

- Implementation

- Challenges

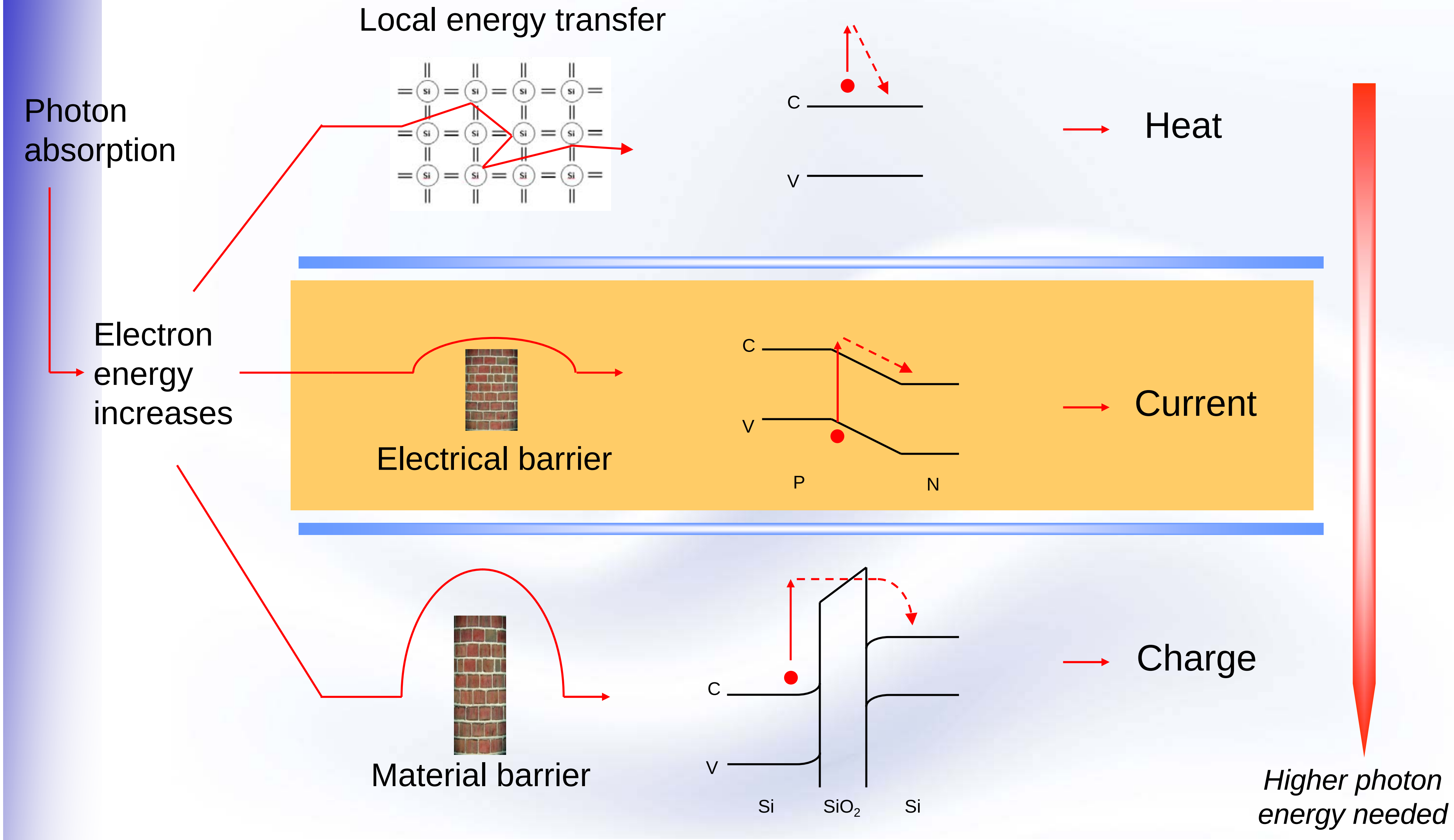
- Conclusions

Introduction

- Laser-based optical techniques

Stimulation / Analysis Electrical Optical	Static	Dynamic
Static	OBIC, OBIRCH, LIVA, TIVA, SEI	SDL, LADA
Dynamic	Lock-in OBIRCH, Pulsed-OBIC, **PULS**	SEET, LVP, **TRLS**

Optoelectronic effects



Photon absorption

Electron energy increases

Local energy transfer

→ Heat

Electrical barrier

→ Current

Material barrier

→ Charge

Higher photon energy needed

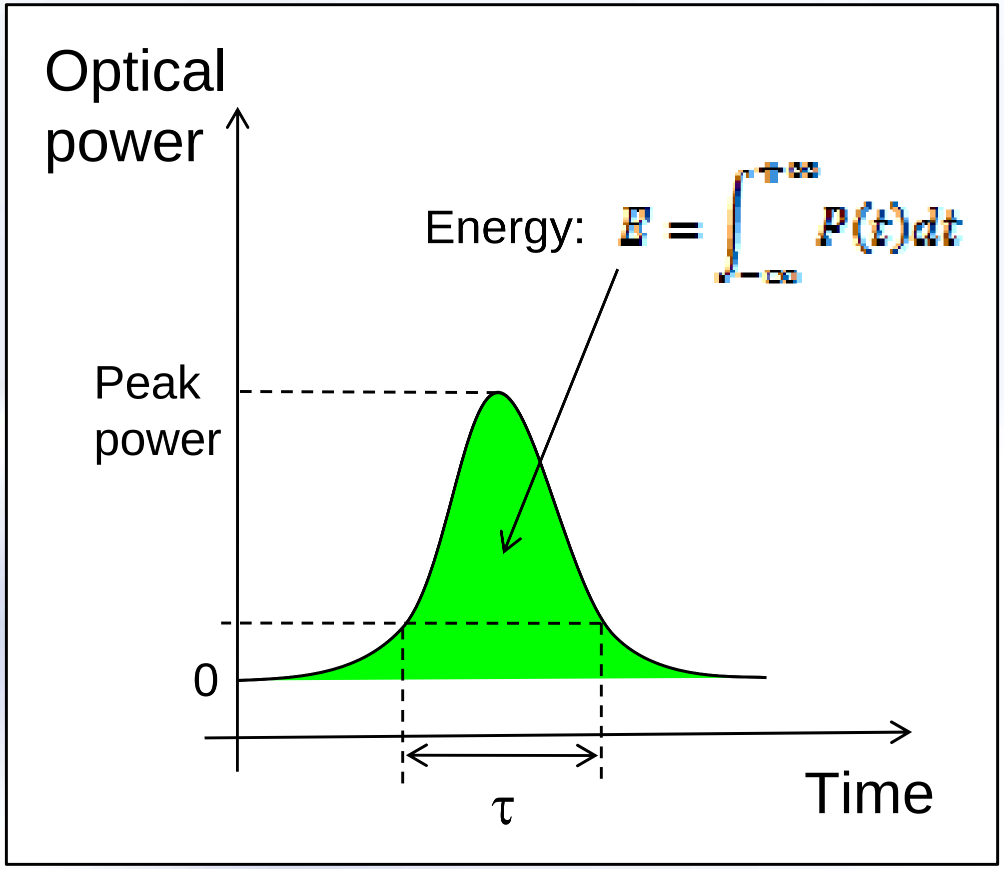
Different laser-induced faults

Mode	Electrical modelling	Parametric fault	Logical fault	Degradation
Photoelectrical	- Photocurrent	- Commutation time - Supply current	- Timing error - Transient - Bit flip	- Latchup - Breakdown - Fusion
Photothermal	- Resistivity - Leakage current	- Commutation time - Propagation time - Supply current	- Timing error - Transient - Bit flip	- Fusion

Laser Power

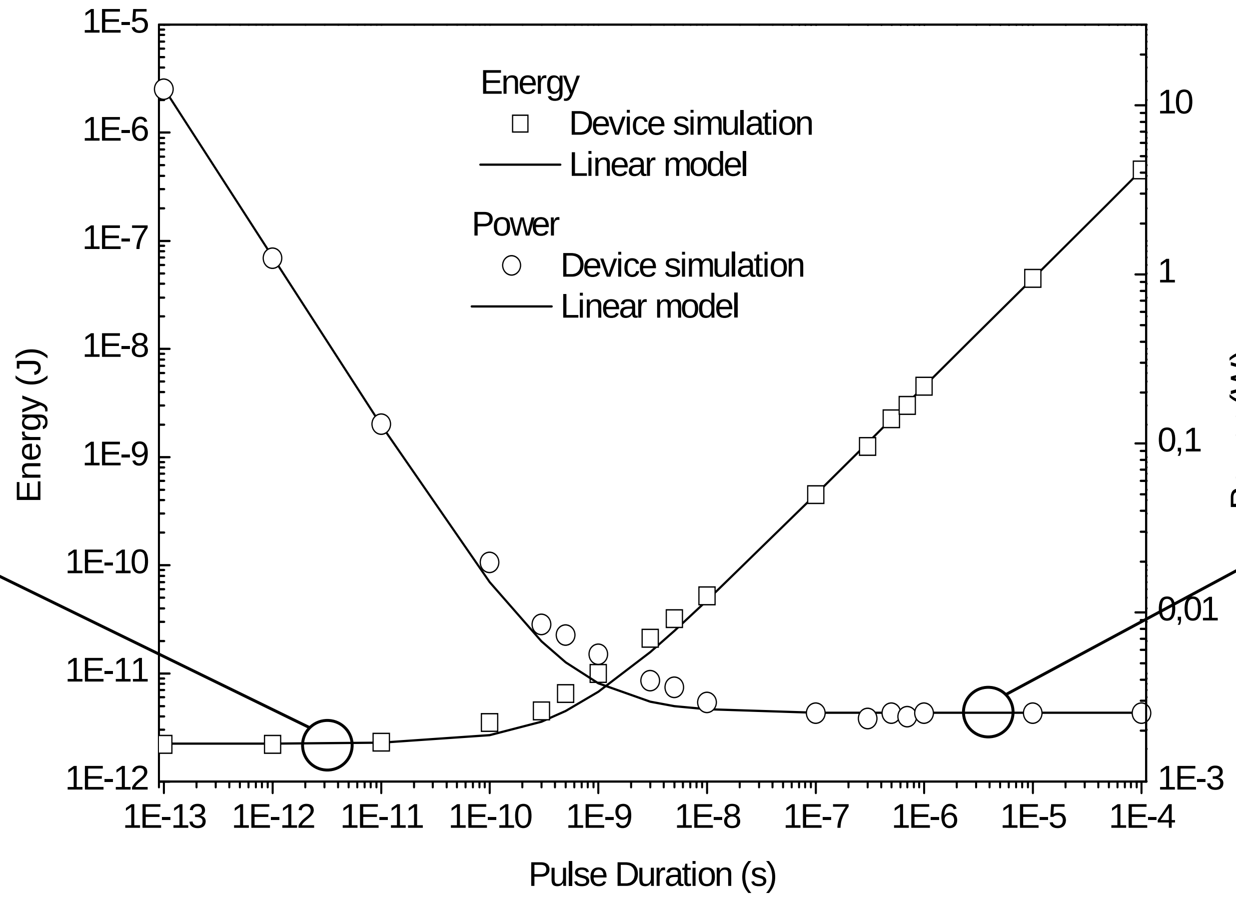
Pulsed laser specifics

- Short pulse
  - Time resolution
  - Wide spectrum
- High peak power
  - High intensity when focused
  - Nonlinear effects
  - Risk of degradation
  - Optical integration constraints
- Limited energy
  - Negligible heating
- Laser source technology



Influence of laser pulse duration

Threshold
pulse energy
for flipping
a logical state

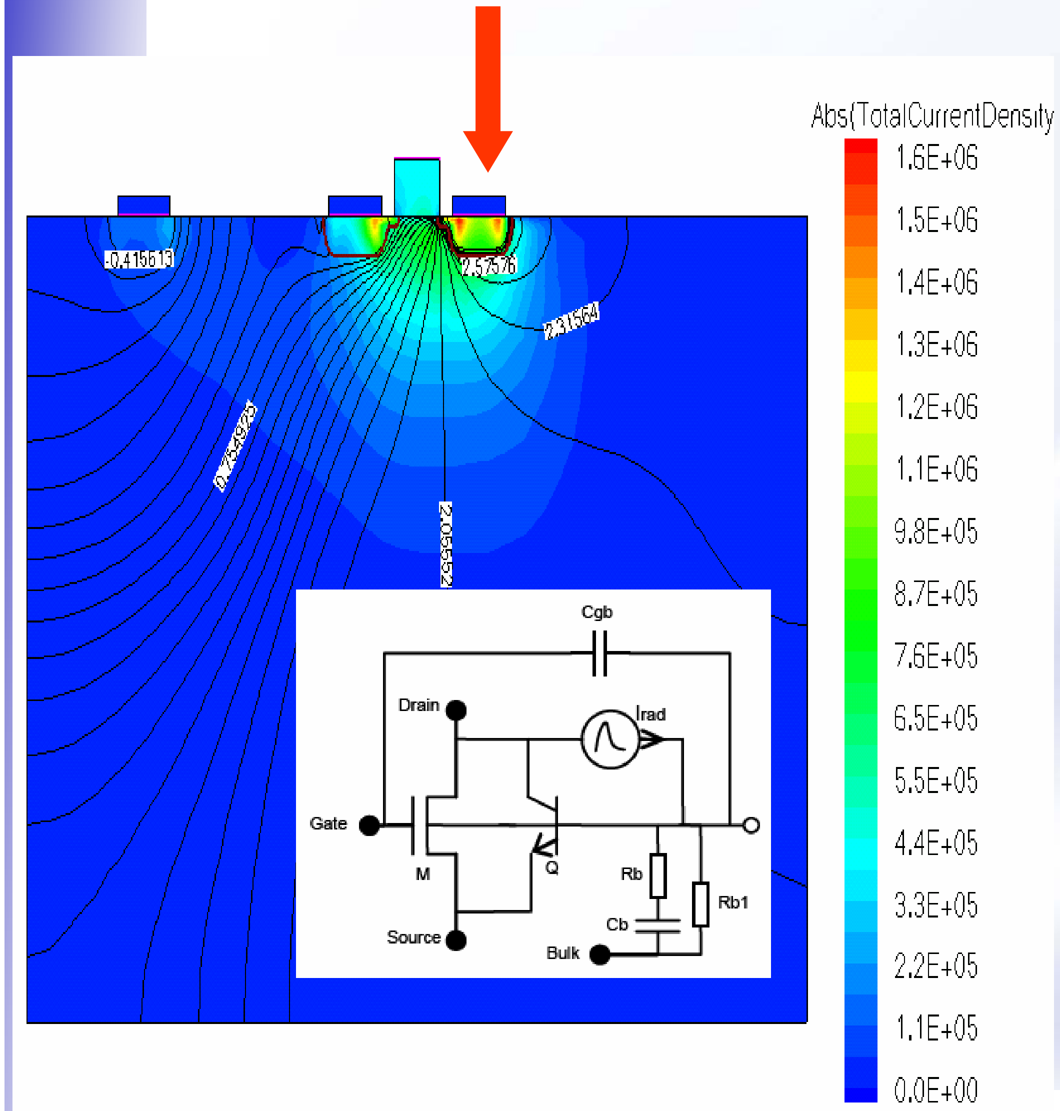


Threshold
peak power
for flipping
a logical state

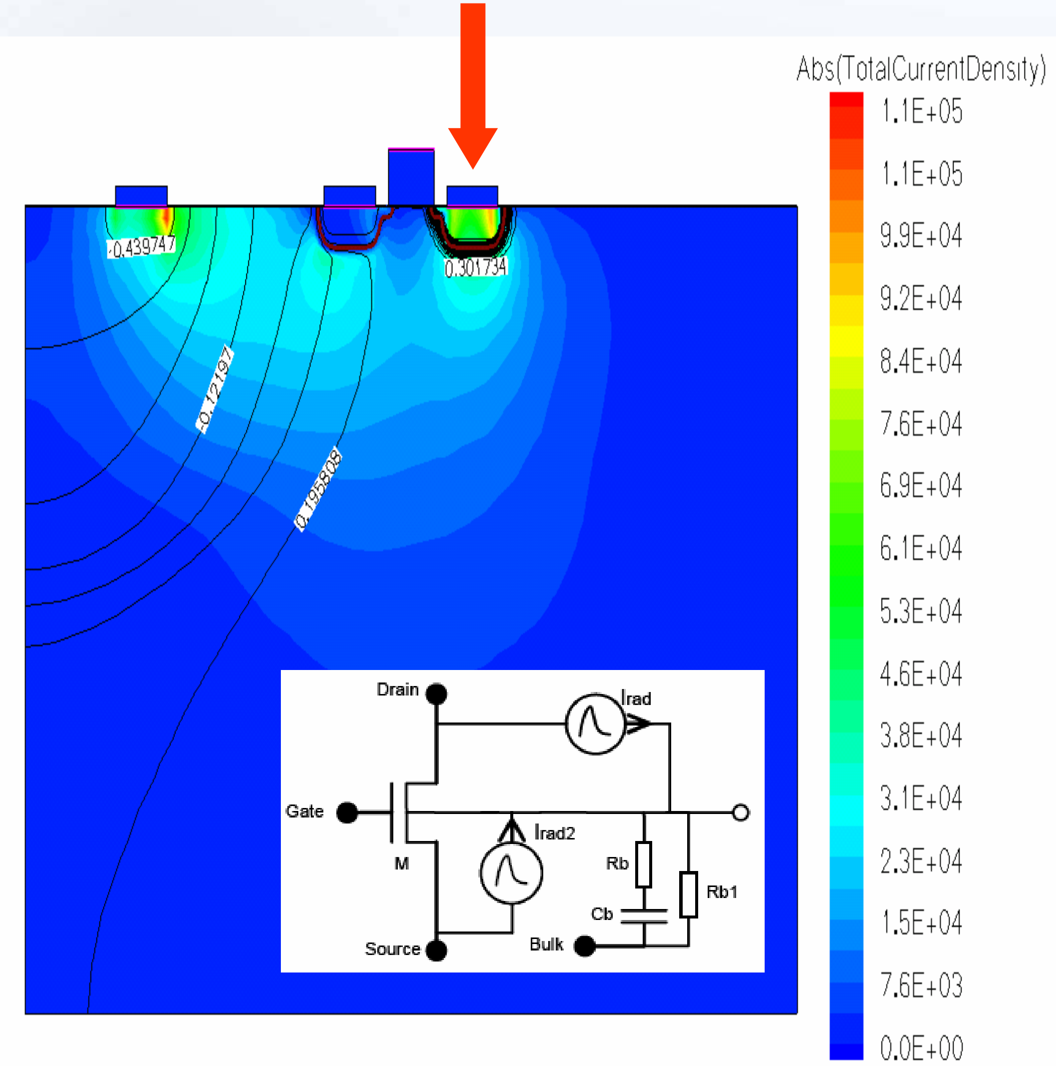
$$E_{th}(\tau) = \frac{E_\gamma}{eT}\left[\frac{q_S}{1-e^{-\alpha d_S}} + \frac{2 i_L \tau}{1-e^{-\alpha d_L}}\right]$$

Influence of laser pulse duration

Laser pulse
1ps - 2.5pJ

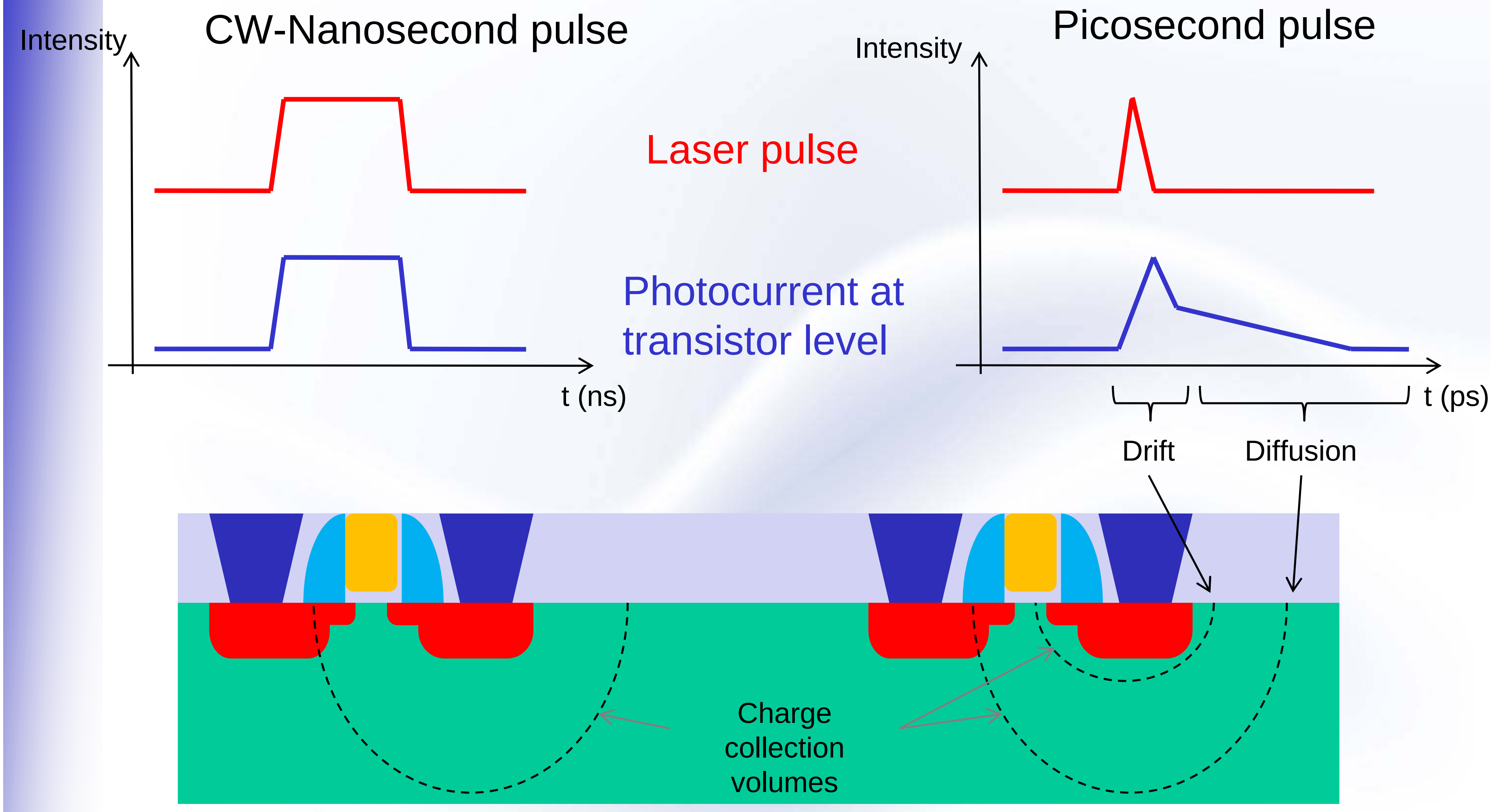


Laser pulse
1ns - 10pJ



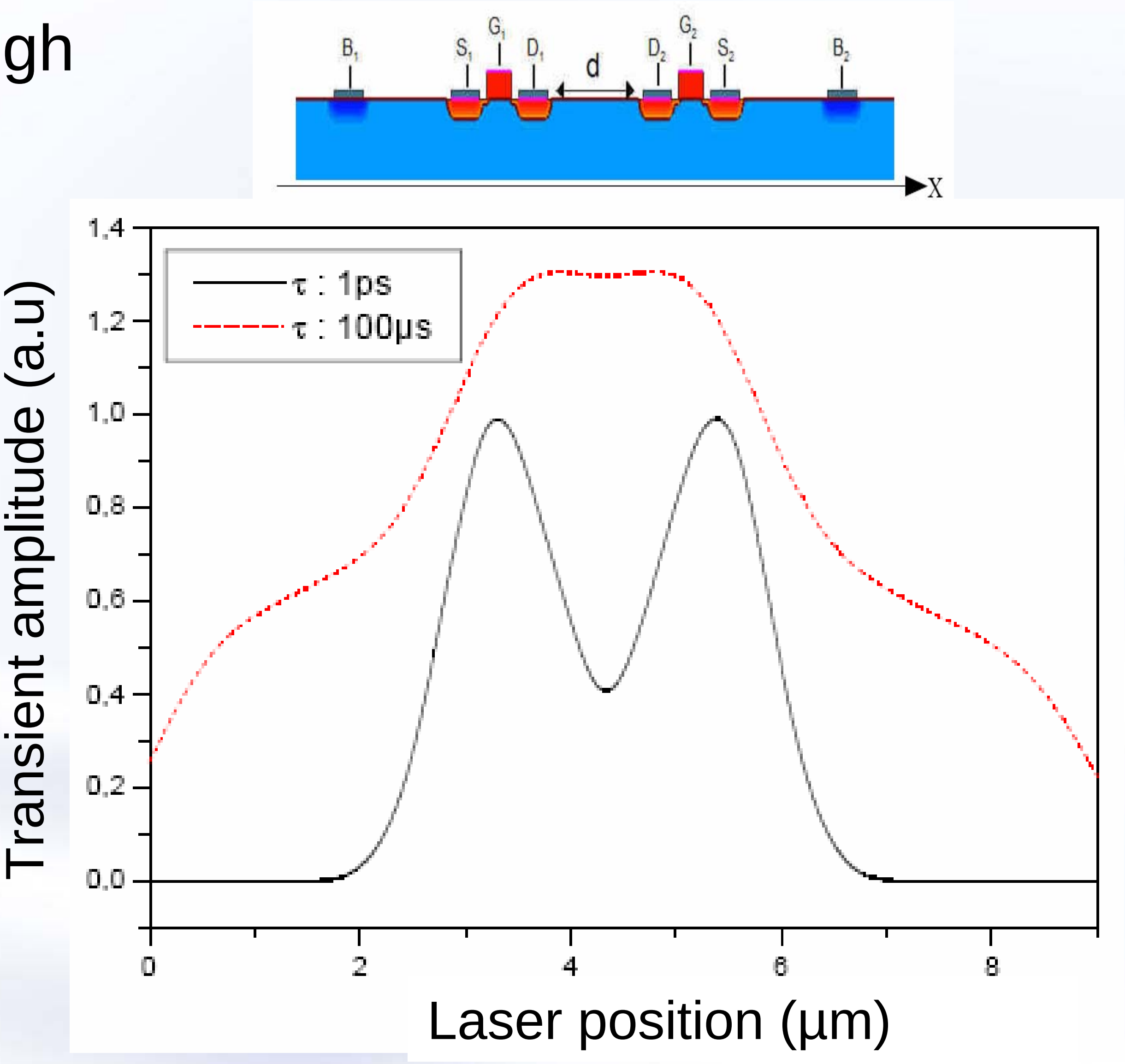
A. DOUIN, PhD thesis, 2008

Charge collection mechanisms in Pulsed OBIC



TCAD simulation of resolution improvement

- Scanning through two transistors

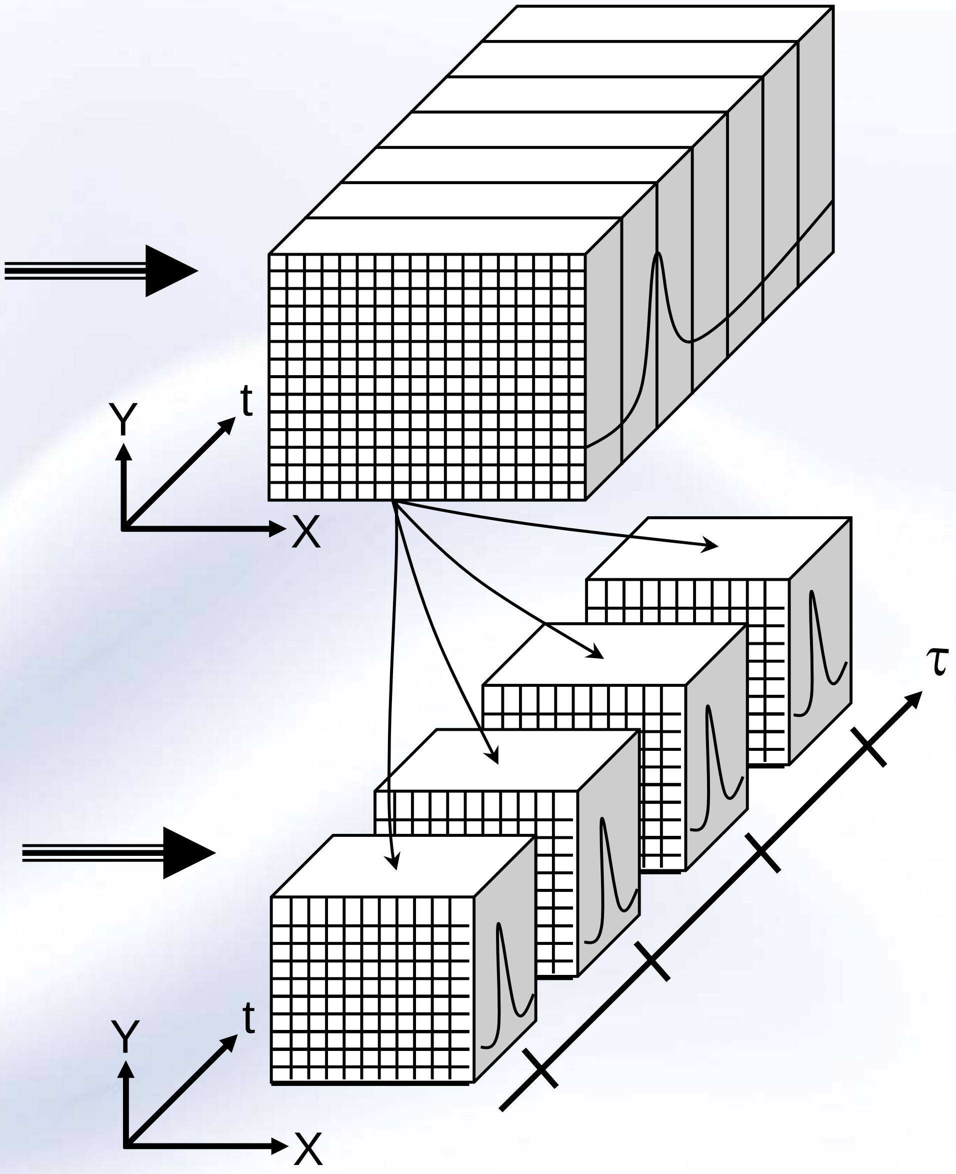


Applications

- Failure analysis
  - Defect localisation (current paths, timing errors…)
  - Design debug by transient parametric or logical fault injection
  - Latchup & latent defect localization
- Radiation effects testing
  - Single-event effects
  - Technology evaluation & qualification
  - Parts screening
  - Reverse engineering
- Security evaluation
  - Fault injection
  - Functionnal analysis

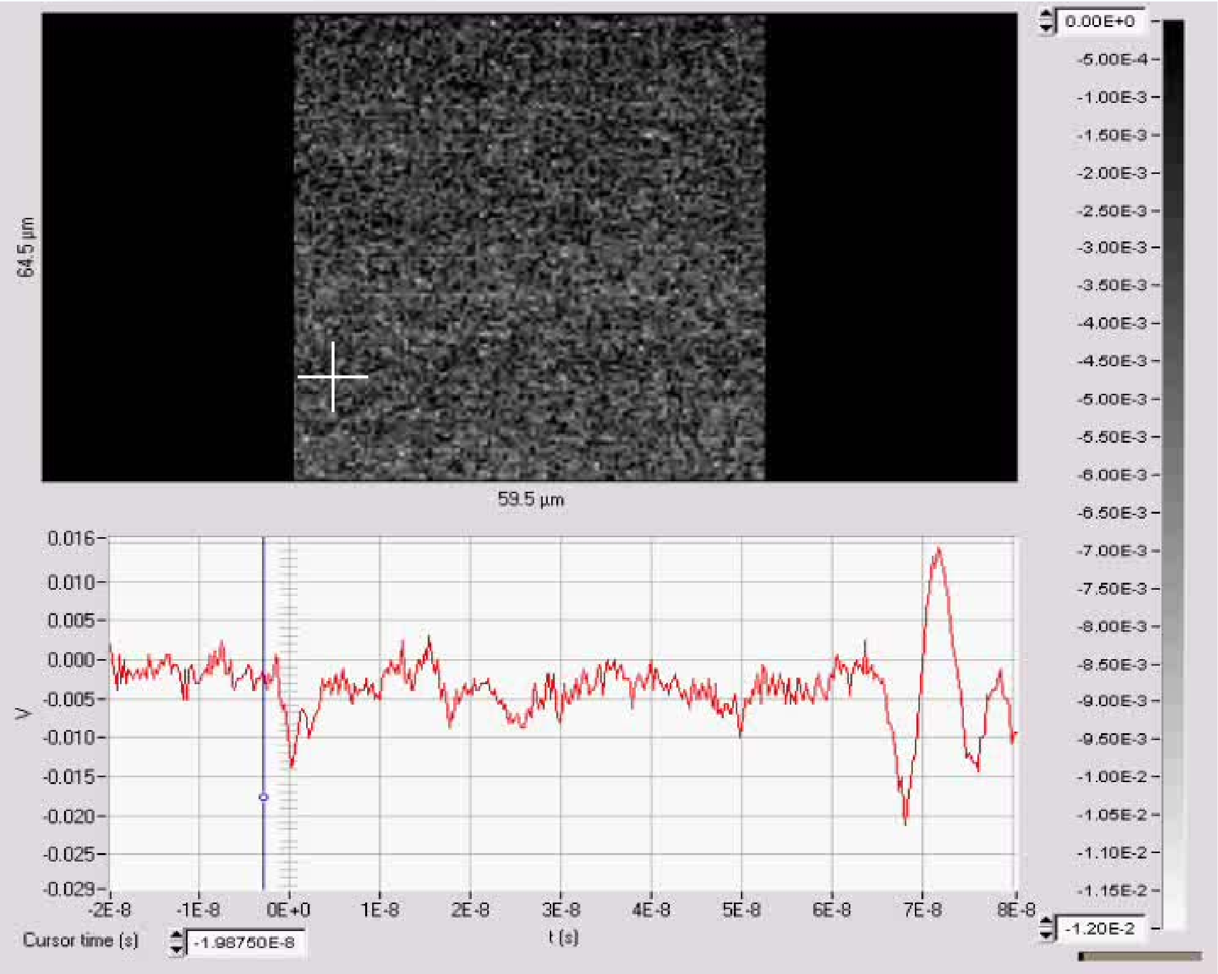
Methodology

- PULS Technique
  - Static electrical stimulation
  - Imaging of the transient response on an output or on the supply current
- TRLS Technique
  - Dynamic electrical stimulation
  - Synchronization between Test Pattern and Laser Pulse
  - Measurement of the laser induced transient on the output for different delays τ



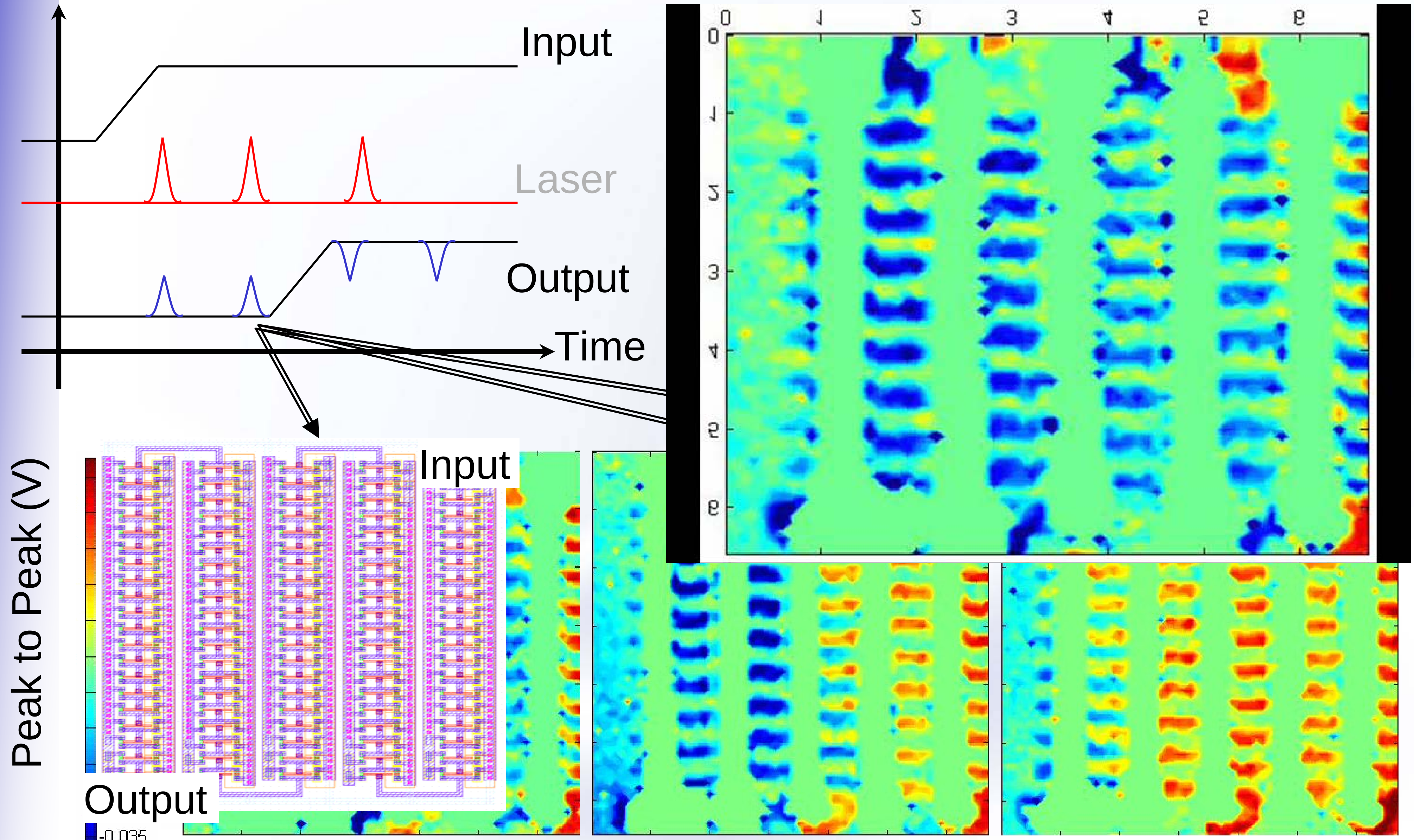
PULS Results

- Scanning of an inverter chain
- Imaging of output signal amplitude in grey scale
- Visualization of the propagation of the laser-induced glitch
- Later sampling times = upstream the chain



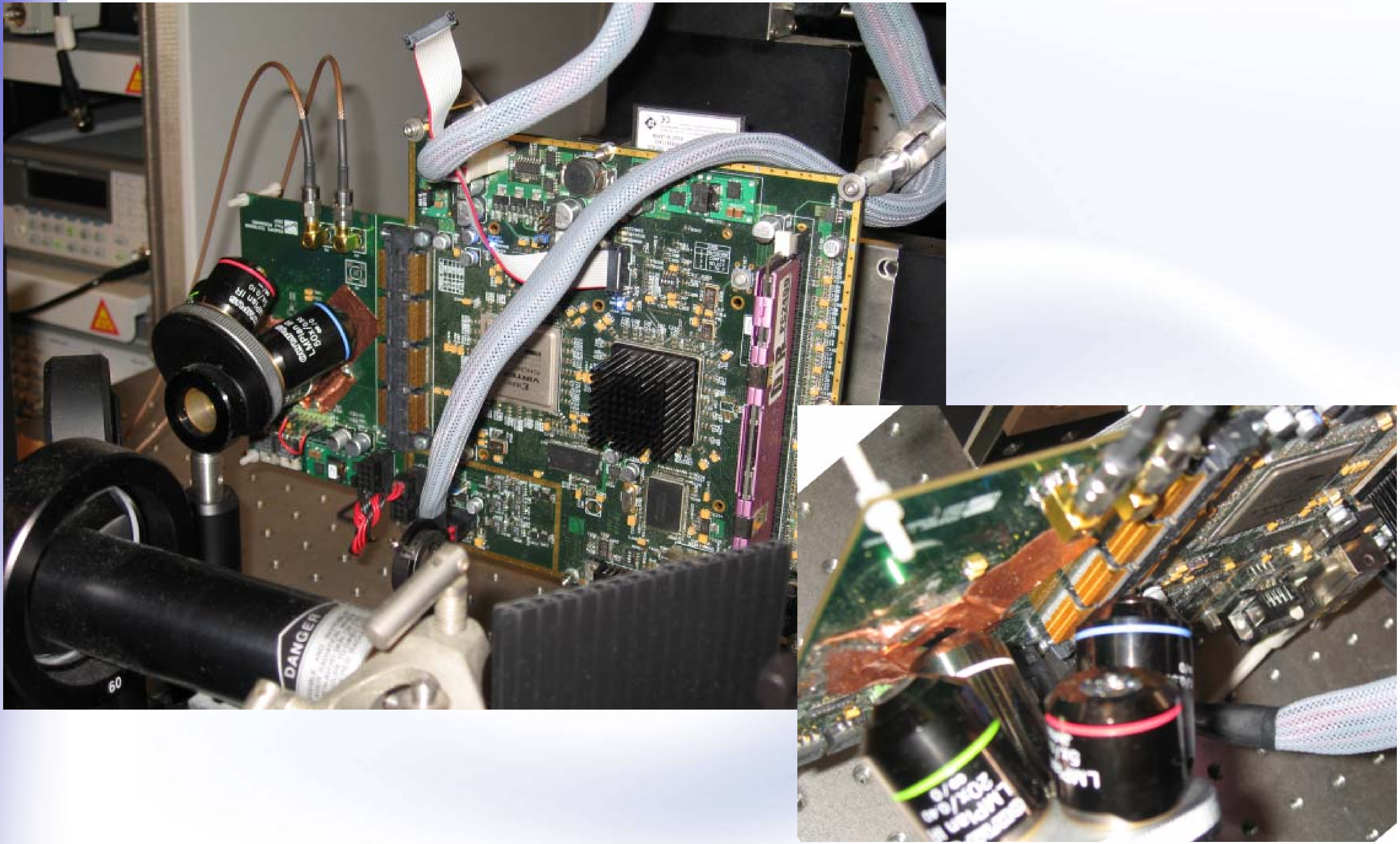
Cursor time (s) -1.98750E-8

TRLS Results

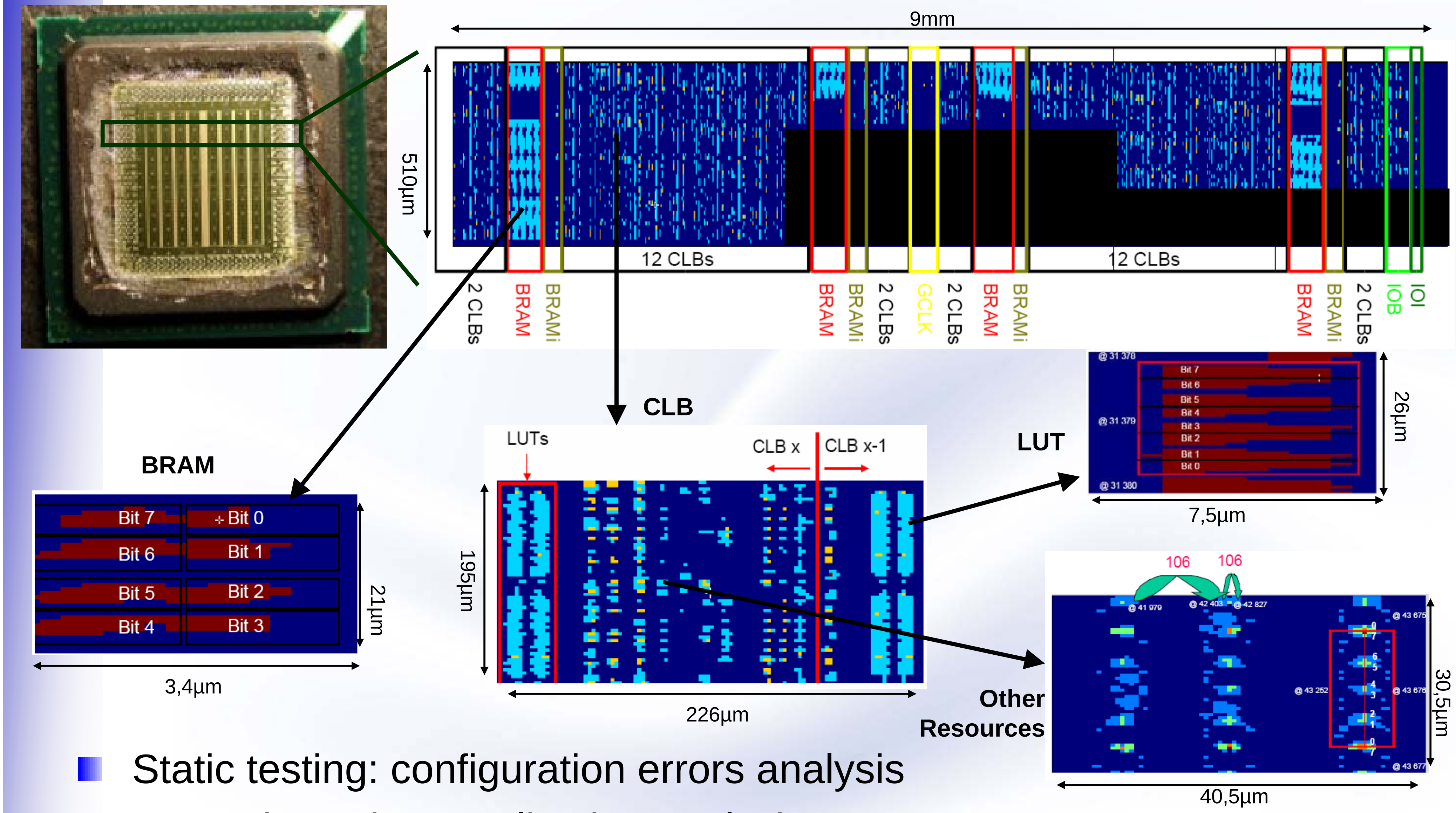


τ =2ns τ =6ns τ =10ns

Time-resolved laser fault injection

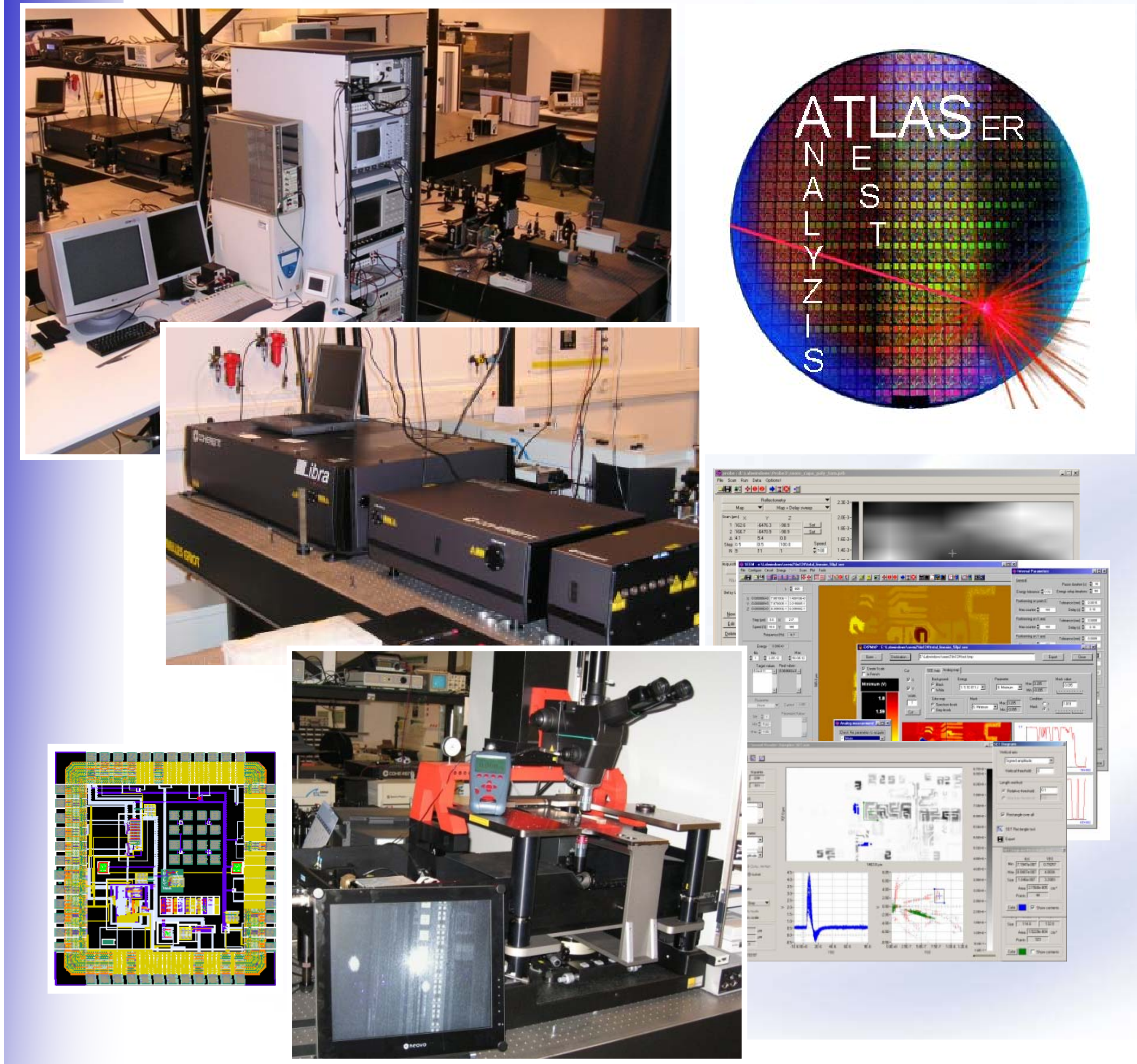


Errors Mappings in an SRAM-based FPGA



- Static testing: configuration errors analysis
- Dynamic testing: application analysis

ATLAS Laser Facilities at IMS



- NIR-tunable Picosecond laser source
- Amplified Femtosecond parametric laser source
- Computer controlled tunability : 400 - 2500 nm
- Energy : up to 1 mJ
- Picosecond synchronization of laser pulse with test vector
- 5 laser-injected microscopes
- Backside testing
- Microprobing station with backside laser scanning microscope
- Dedicated test chips
- Fully automated
- ATLAS-i : compact version dedicated to radiation testing services

PULSCAN

- Created in 2008, laureate of 2008 French trophy for innovating technology company creation
- Pulsed laser modules and systems for IC testing & FA
- Custom optical design and integration services
- Compact digital test systems for design debug & qualification
- Custom electronic testbeds for at-speed and remote testing
- Laser testing services on ATLAS & ATLAS-i

PULSCAN

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REGION AQUITAINE

Tima

Route des Lasers

ALPhA NOV

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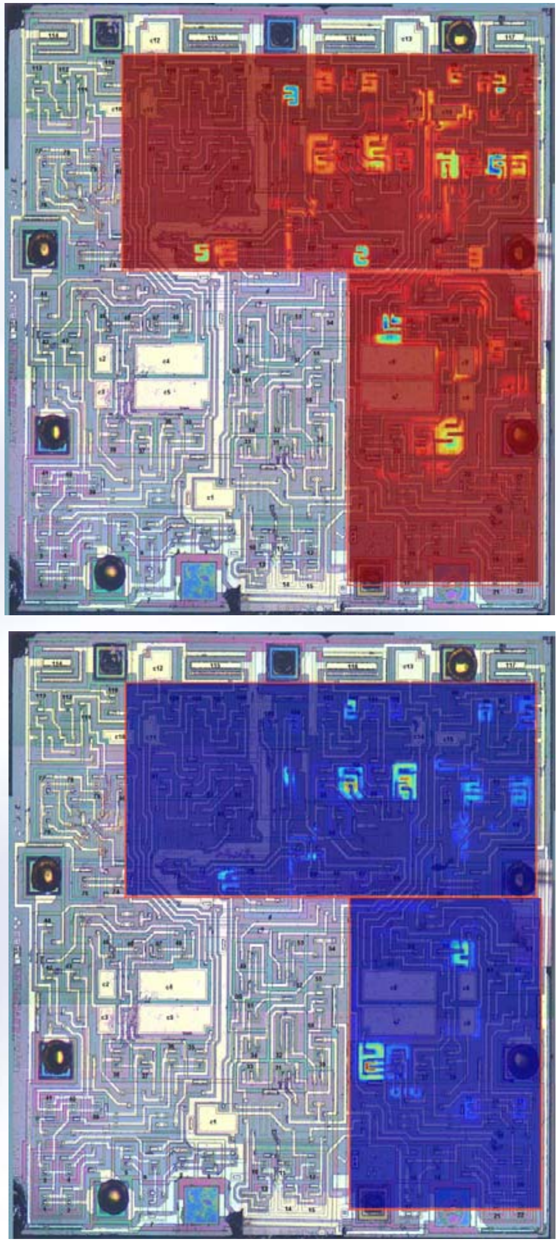
INCUBATEUR RÉGIONAL D'AQUITAINE

Challenges

- Resolution
  - Improved, but still a laser technique
- Transient signal observability
  - Rely on DUT as the detector
- Latchup sensitivity
  - Backside pulsed OBIC can easily trigger parasitic structures
- Laser energy
  - Working between signal and degradation thresholds
- Laser-ATE synchronization
  - Jitter as low as 20ps can be achieved but simpler electrical set-up needed.
- Methodology
  - One more dimension to consider (pulse-clock delay)
  - More information can be extracted at each pixel



Conclusions

- Picosecond laser stimulation
- Improved time resolution & at speed testing
- Spatial resolution improvement (to be quantified)
- Several applications of interest for FA labs customers
- First industrial prototype in 2009
- Silicon for case studies welcome
- Work in progress on the next step in pulsed laser approaches: femtosecond techniques (TPA, EFISH…)