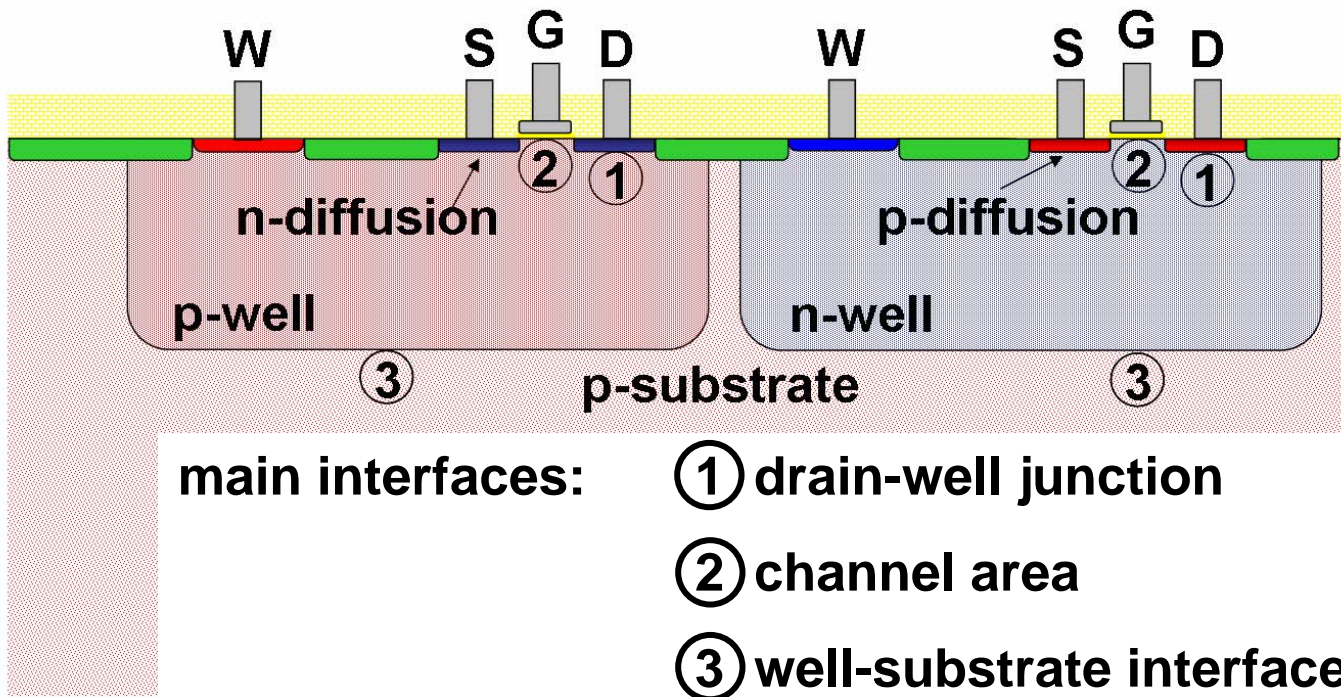# LVP Signal – Where to Probe? Modulation Mapping *or* LVI

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LVP signal origin
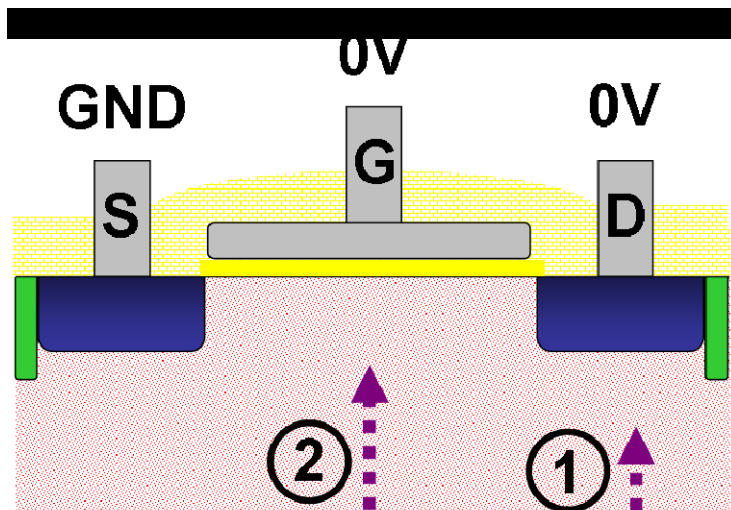
- Laser beam is focused on the DUT (through the backside)

- Gets reflected at many different interfaces

main interfaces: ① drain-well junction
② channel area
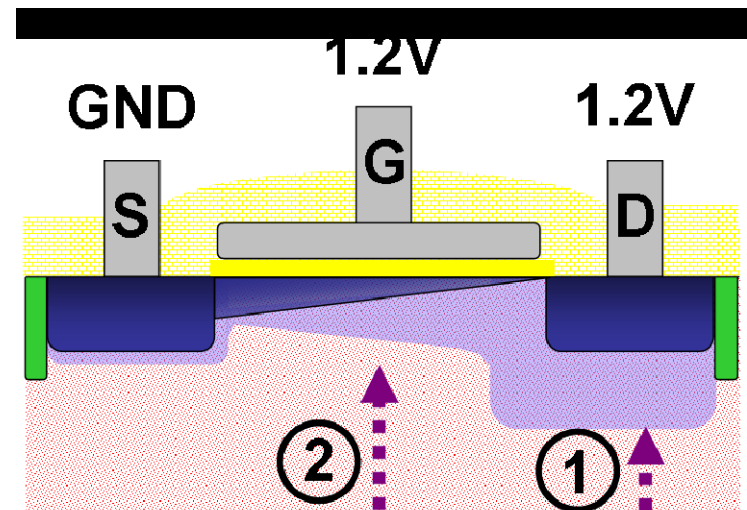③ well-substrate interface

LVP signal origin

- Modulation of the reflected light due to different switching states
  - Inversion channel charge carrier density
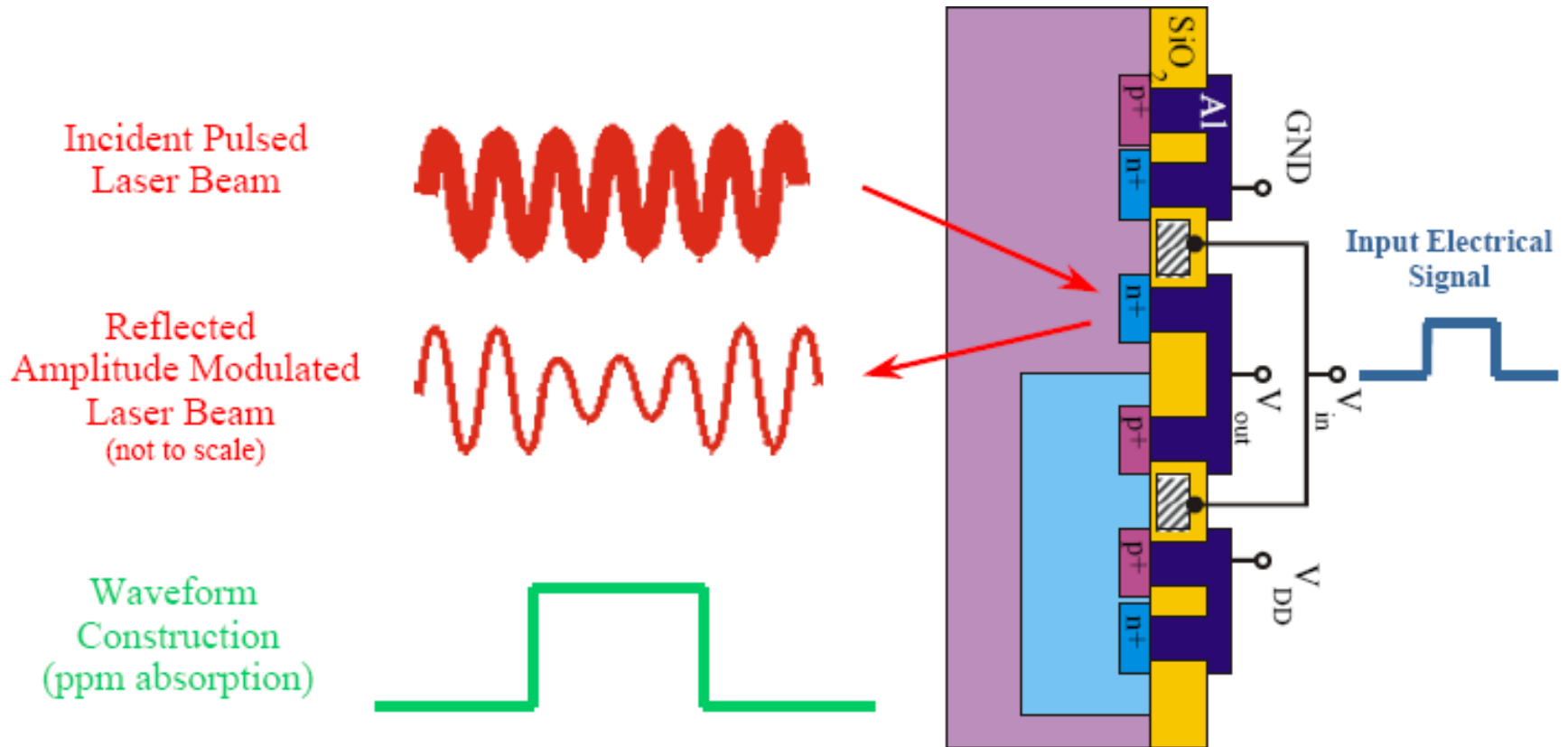 - Depleting space charge region

off state
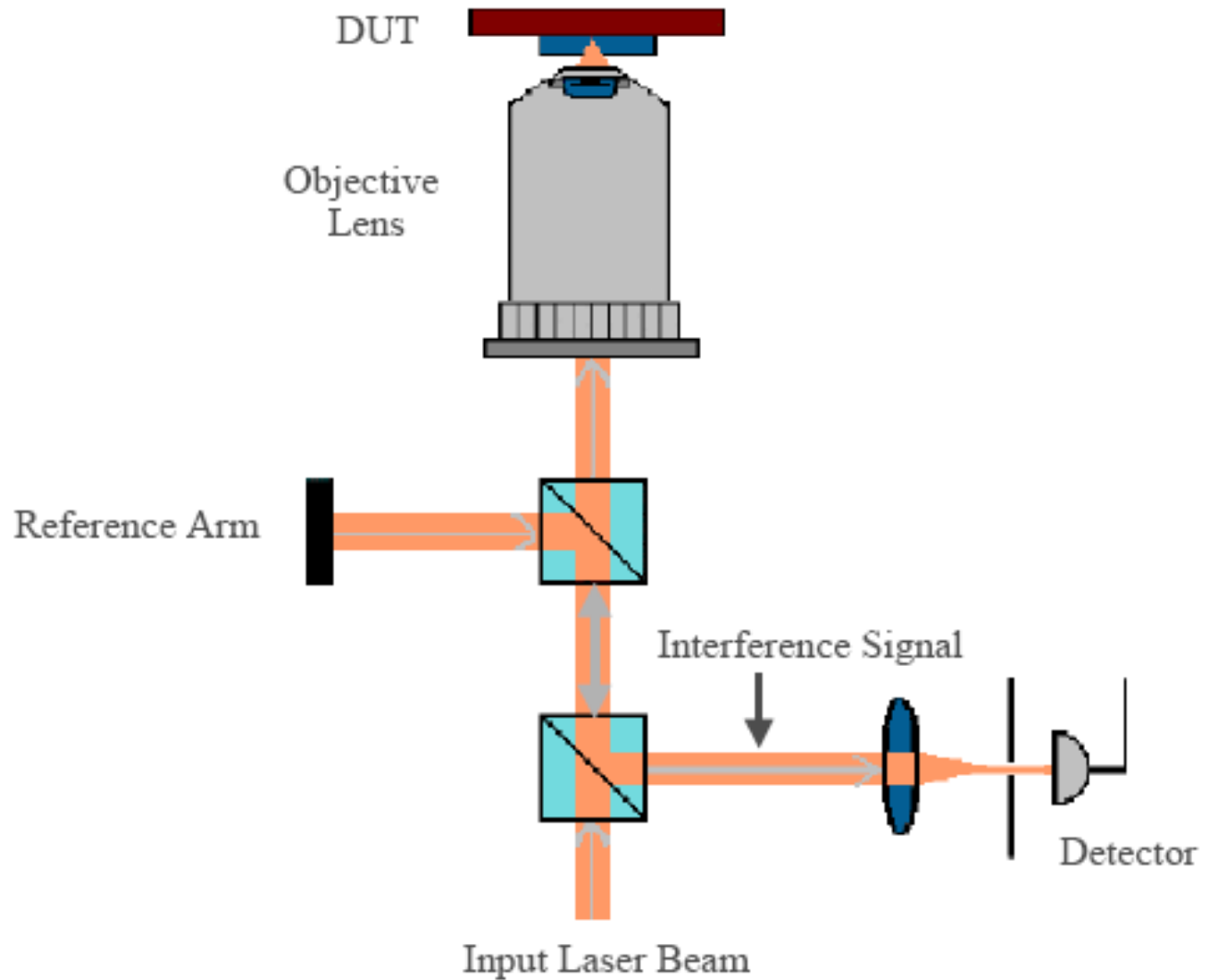
on state – saturation

Note: E-Fields in devices are contributing two orders of magnitude lower signal than free carrier effects!
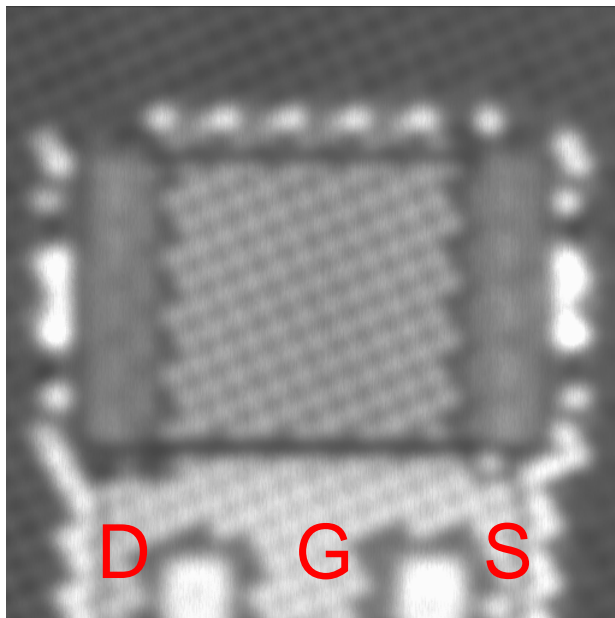
Amplitude modulation detection
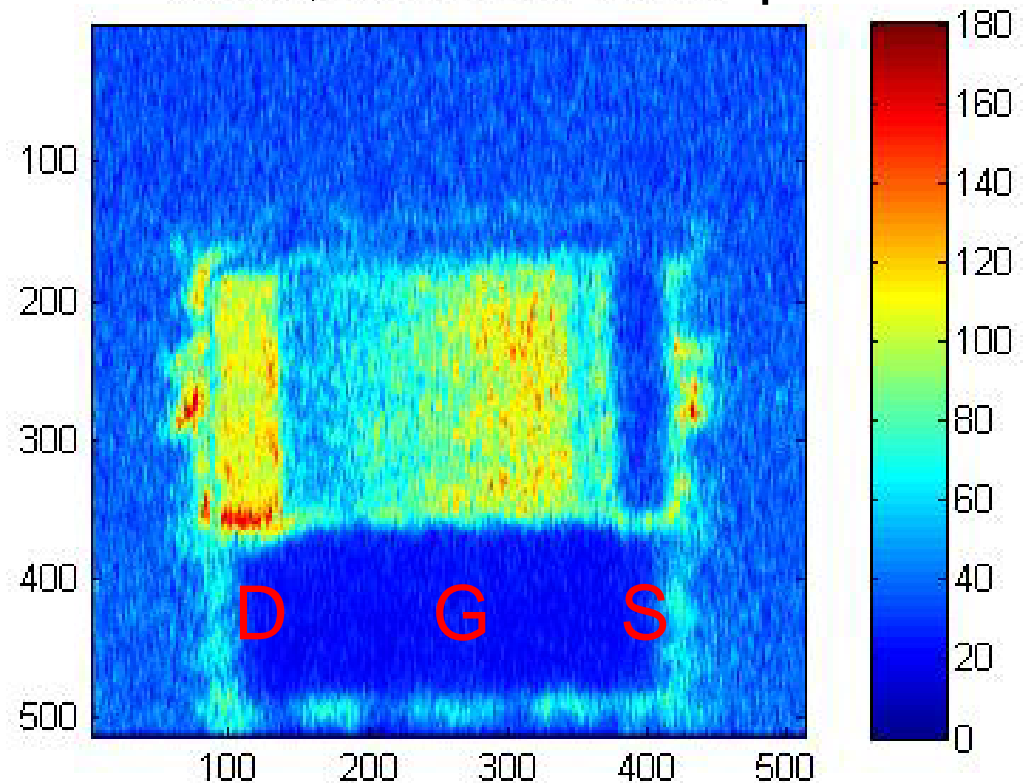
Phase interference detection scheme

Proof of LVP signal origin

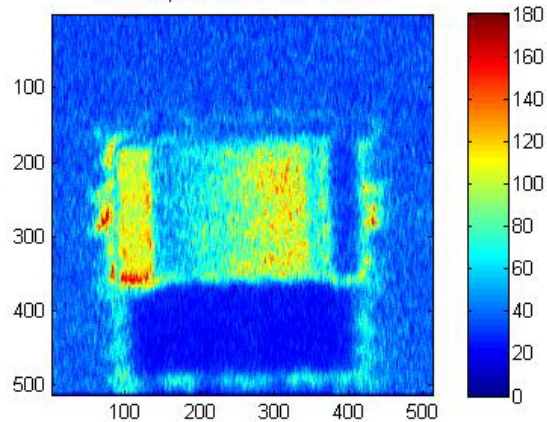Modulation mapping is used to show the origin of LVP signal
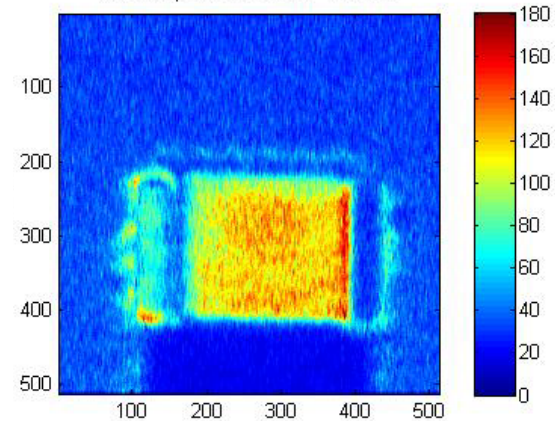
LSM image

Modulation map

modulation map for
Vg=Vd=1.2V pulsed

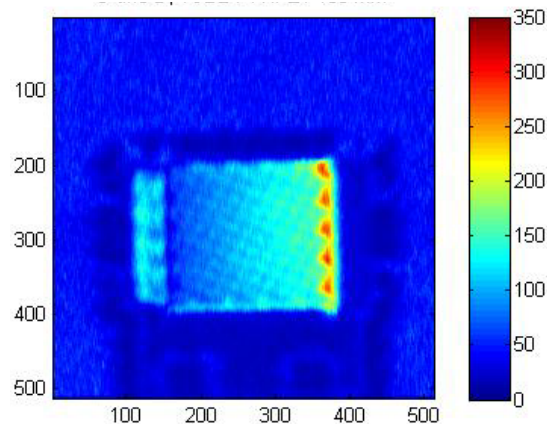*Joint work between TU Berlin and DCG*
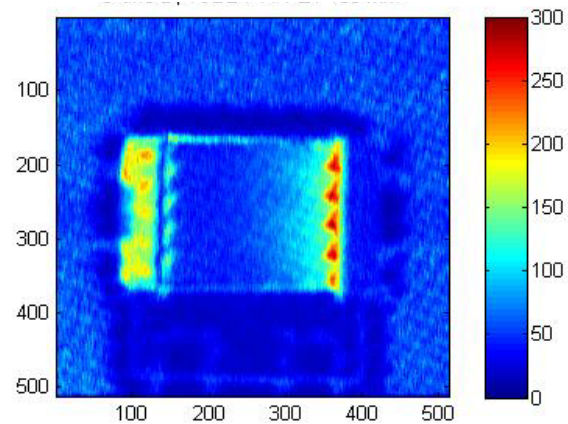
Different Wavelength and Device
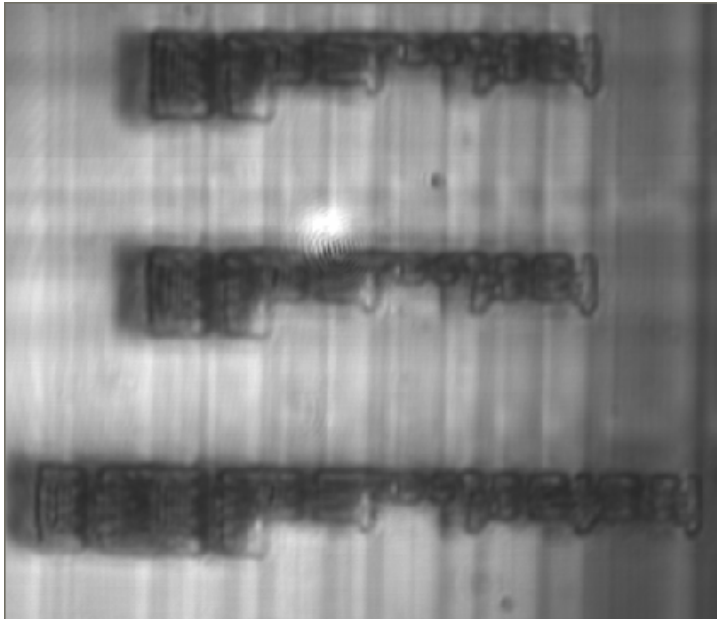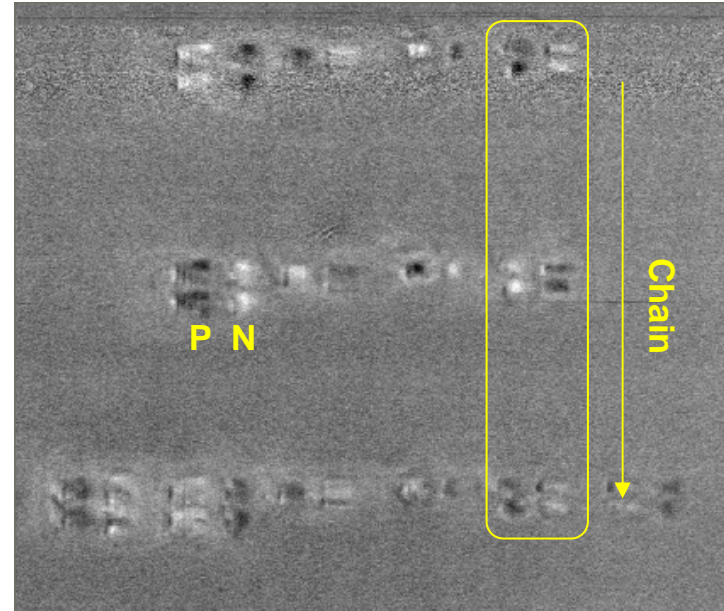
- NFET 1319nm

- PFET 1319nm

- NFET 1064nm

- PFET 1064nm

ModMap on Inverter Chain
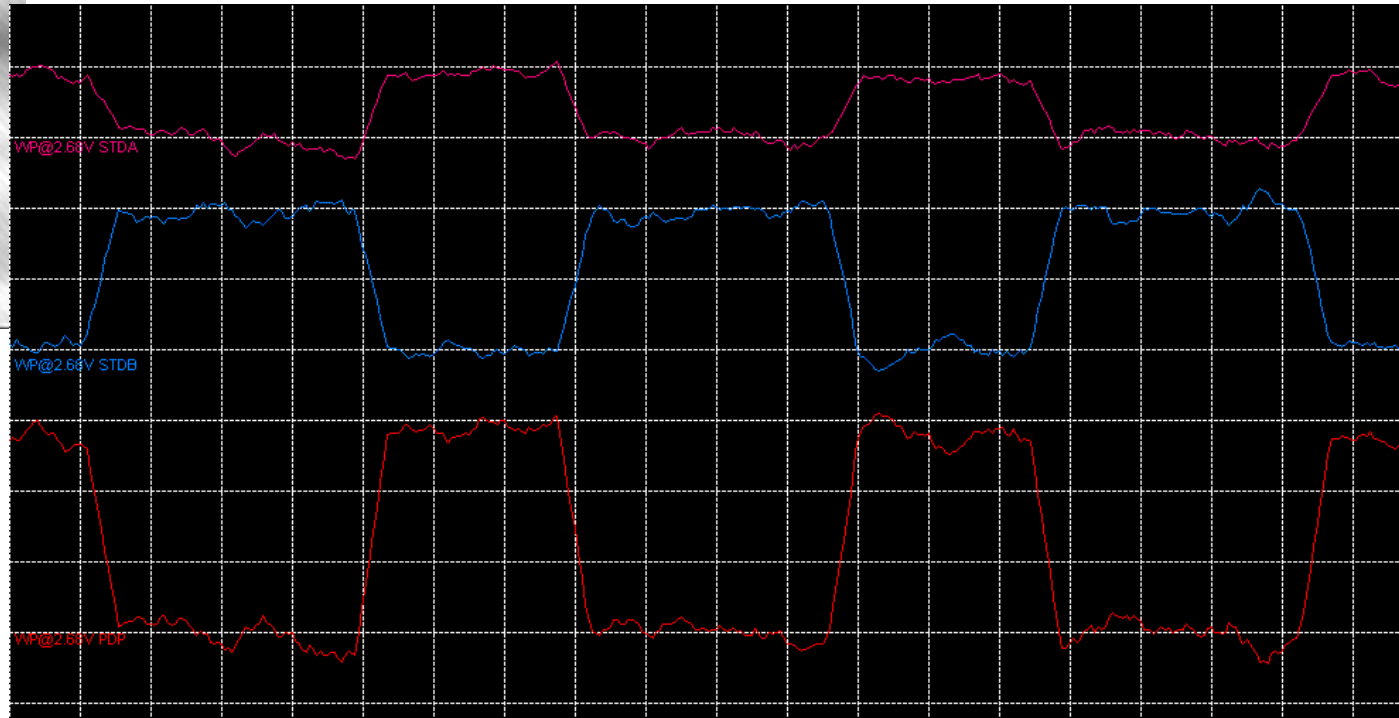
LSM image

Modulation Map

- A slight different setup is used in this modulation map.
- The noise level is shifted to mid range of the data acquisition apparatus. Any increase or decrease in the reflectance cause by LVP modulation is detected darker or brighter pixels in the modulation map.
- In this simple case, it is observed that
  - **The PMOS and NMOS have opposite polarity as expected.**
  - **The inverted states between the adjacent stages of the inverters in a particular chain.**

Probe the inverter chain using LVP tool
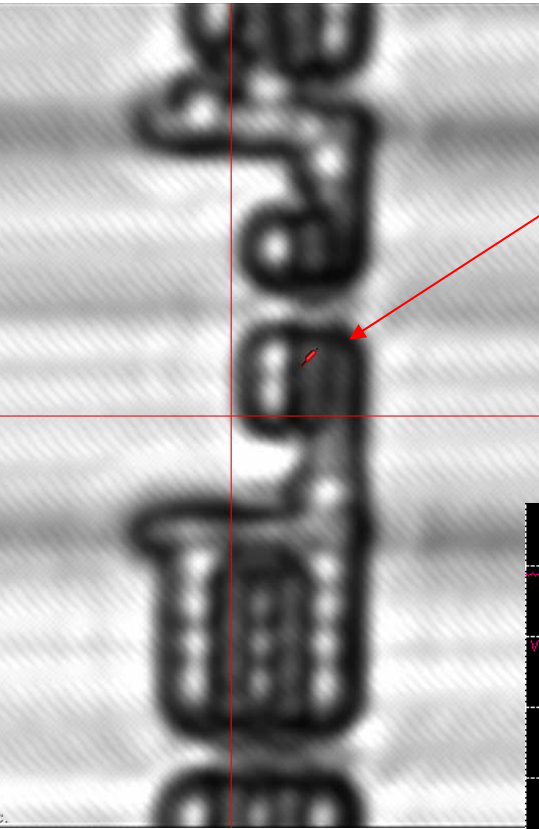
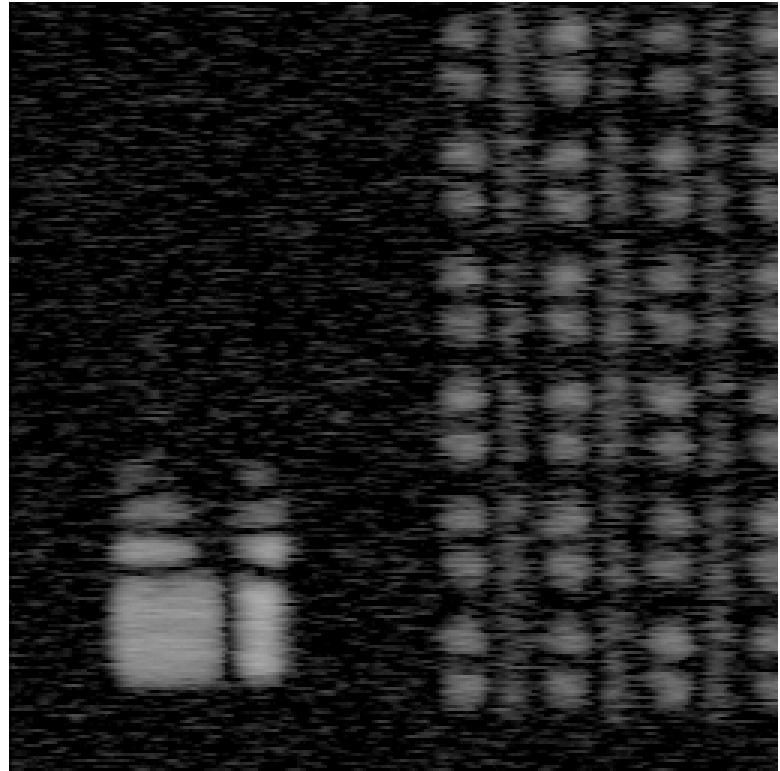LSM image with probe placement

Waveforms

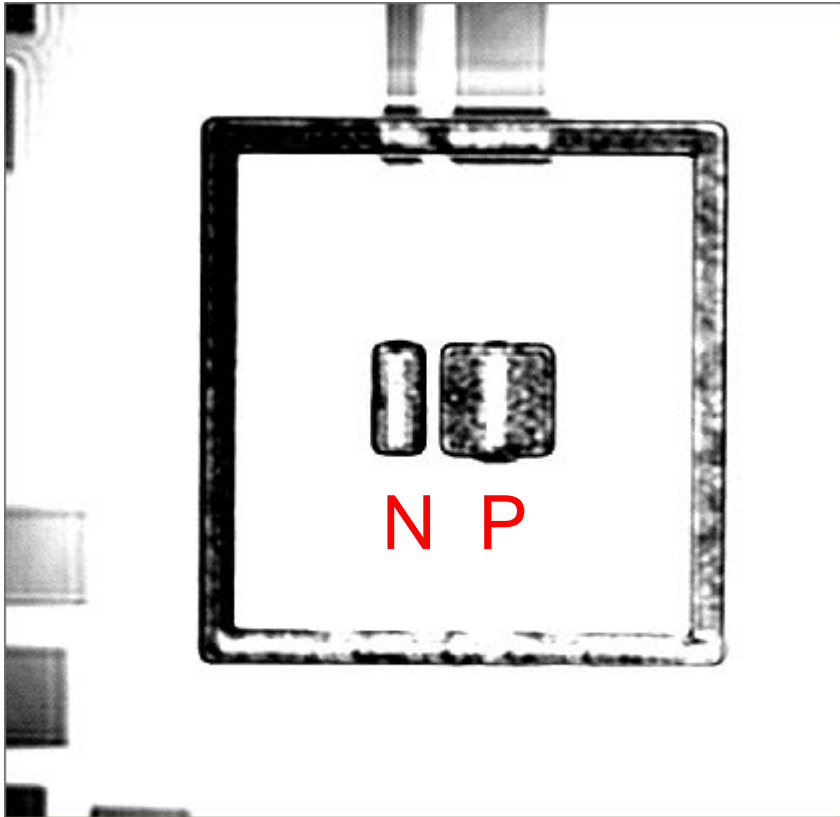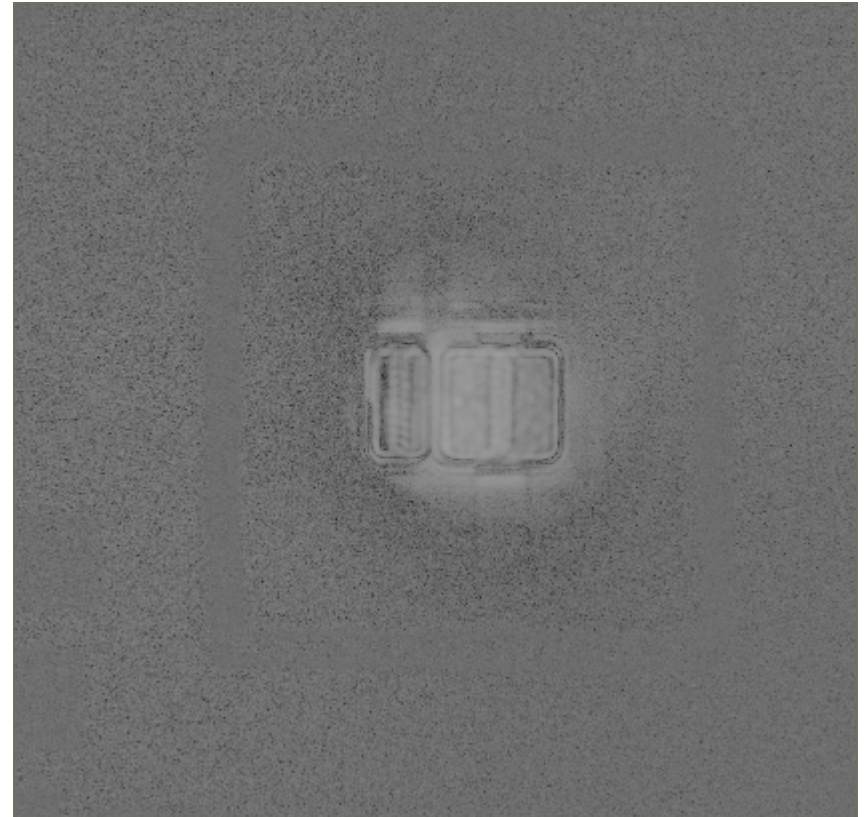# ModMap on SOI Devices

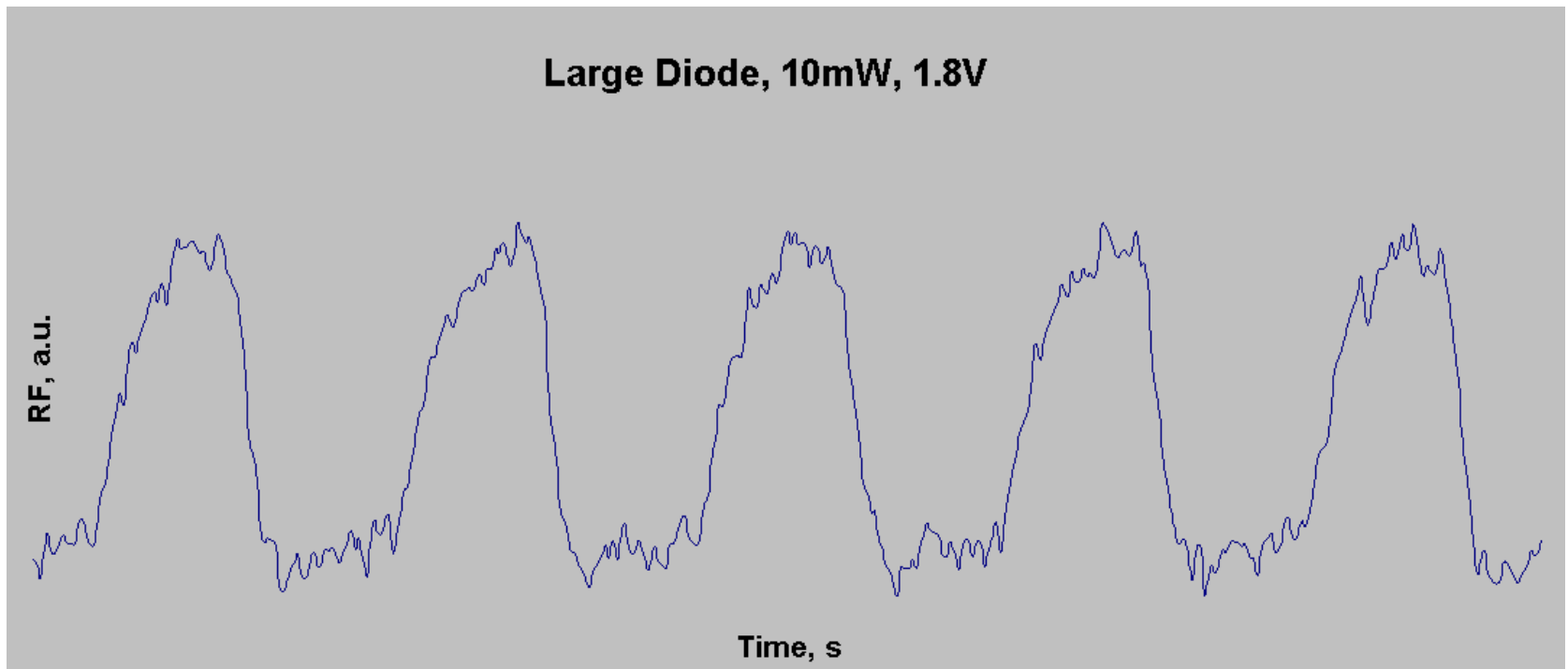LSM image

Modulation Map

ModMap on Diode Structure

LSM image

Modulation Map

Probe the Signal!

- Once modulation map pinpoints activity in the transistor of interest, waveform acquisition can done!

Large Diode, 10mW, 1.8V

CONCLUSION

- Modulation mapping or Laser Voltage Imaging can be used to show electrical activity on the DUT

- Same setup can be used to perform LVP at relatively low bandwidth (few GHz)

- Dedicated tools provide much higher bandwidth (20 GHz) like DCG Ruby