

First results from the new edge-TCT setup at the University of Hamburg

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- 1. Setup and Samples
- 2. Measurements at Different Focus Positions
- 3. Light Attenuation in Silicon
- 4. Summary and Outlook





- Design modification by Uni HH / DESY *
- Two r/o channels
- Top/bottom and edge illumination
- PT-100 on second pad
- Anodized Al box

Optimizations:

- Enlarged light openings
- Wider slit in the PCB
- More space between PCB and cover

* Talk by Hendrik Jansen at 1st TCT Workshop https://indico.desy.de/conferenceDisplay.py?confId=12934





Mounting

- Mount on Al plate
- Backside cooling
- Fixation pins for position reproducibility
- Easy switching between top and edge illumination
- Clamp to avoid vibrations





- N-type strip sensor (CiS)
- Thickness: 285 ± 2 μm
- Pitch: 80 μm
- Implant-width: 18 μm
- Pad diode depletion: 45 V
- 4th and 9th strip r/o
- Grounded via 50 Ω
- Polishing procedure:

see S. Wonsak talk at 1st TCT workshop:

https://indico.desy.de/conferenceDisplay.py?confId=12934





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Sample



Setup properties

Laser properties

- Rate: 1kHz, wavelngth: 1052 nm
 - 3*10⁵ carriers /strip/pulse = 4*10¹⁴ / cm³ same order as seen by J. Becker * → Plasma effect?

Laser beam width

Focus on cut edge:

- Width at edge 8.4 μ m FWHM (Int.)
- Width at strip 39 μm FWHM

Focus on strip:

- Optical system moved by S=378 μm
- Width at strip 8.4 μ m FWHM (Int.)
- Width at edge 39 μ m FWHM

* J. Becker, et al., Nucl. Instr. and Meth. A (2010), doi:10.1016/j.nima.2010.10.010





Pulse shape at various laser focus



- Strong oscillations
- Different amplitudes after rise
 → higher charge densities?
 → Plasma effect?
- Different slope at signal fall
 → different beam widths?



 No change in pulse shape when moving focus ~ 300 μm

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Pulse analysis





- Pulse analysis $Q = \int_{35ns}^{65ns} Idt$
- Integration window chosen to minimize noise contribution

Signal degradation at sensor edges:

- light loss = charge loss
- light scattering = triangular pulse



Charge Profiles



- Profile depends on the integration
- Peak at the backside due to:
 - field at the n-n+ junction
 - light scattering at sensor edge
- Loss of charge close to backside (e.g. for x > 200 µm) → reason?



- Charge loss at edges smeared by beam width
- Different profile in the bulk



Prompt Current Measurements



Prompt current:

$$Q_{prompt} = \int_{t_1}^{t_2} \frac{I}{Q_{tot}} dt$$

- T1 = 36.9, t2 = 37.1
- Normalization corrects light loss at the edges



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Prompt Current



- Normalization effects mainly Qprompt values at the edges
- Larger effect for laser focus on strip \rightarrow larger losses for broader beam at edge

Next Step: Calculate electric field and study the impact of the normalization!

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Motivation:

CCE measurements by C. Scharf on irradiated pad diodes Presented at RD50 meeting https://indico.cern.ch/event/456679/contributions/1126306/



Now we know $\lambda_{e,h} \rightarrow$ Determine CCE for infrared laser ($\lambda_{att} \rightarrow \infty$):

•
$$Q_{IR} \approx Q_{dep,IR} \left(\frac{\lambda_e}{w} \left(1 - \frac{\lambda_e}{w} \left(1 - e^{-\frac{w}{\lambda_e}} \right) \right) + \frac{\lambda_h}{w} \left(1 - \frac{\lambda_h}{w} \left(1 - e^{-\frac{w}{\lambda_h}} \right) \right) \right)$$

Fair approximation for $Q_{dep,IR} = 1.9 \cdot Q_{ref,IR} \rightarrow$ Does the light absorption change?



Method:

Use two read out channels

Place laser focus in between the two r/o strips

Determine linear attenuation coefficient, α for integrated charge in A and B:



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Preliminary results; attenuation measurements at T=-30°C; 1052 nm

Fluence [n _{ea}]	50 V	100 V	150 V	
0	$6.93 \pm 0.18 \mathrm{cm}^{-1}$	$6.86 \pm 0.19 \mathrm{cm^{-1}}$	$6.86 \pm 0.17 \mathrm{cm^{-1}}$	
	150 V	200 V	250 V	
$1.2 imes10^{14}\mathrm{cm}^{-2}$	$7.45 \pm 0.16 \mathrm{cm^{-1}}$	$6.96 \pm 0.12 \mathrm{cm^{-1}}$	$6.75 \pm 0.13 \mathrm{cm^{-1}}$	
	600 V	800 V	1000 V	
$1.14 imes10^{15}\mathrm{cm}^{-2}$	$8.56 \pm 0.23 \mathrm{cm^{-1}}$	$7.54 \pm 0.31 \mathrm{cm^{-1}}$	$7.23 \pm 0.26 \mathrm{cm^{-1}}$	
	Literature [by Green]			
0	6.44 cm ⁻¹			

- Large variation between literature values (here only one reported)
- ~1-2% increase for ϕ ~ 10¹⁵ cm⁻¹
- Decreasing α for increasing V for irradiated samples
- Systematic effects not yet investigated
 - Position dependence (x)
 - Effect of the lasers width

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Summary

- Box and PCB successfully tested \rightarrow available to interested groups
- Setup characterization completed
- Prompt charge requires correction for light loss at sensor edges
- Light attenuation measurements attempted

Outlook

- Improve signal quality (bump oscillations)
- Investigate plasma effect
- Compare results to simulations
- Measure attenuation at higher fluences