Noval THz-Detectors for Traceable THz Power Measurement

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- Absorbers
- Modelling
- Extension to GHz region
- Results
- Power measurement
- Energy measurement
- Rep.rate
Absorbers

organic coating with CNT, thickness about **80 µm**, 

Absorbance(red) Reflectance(blue) and Transmittance ( Black) 

Problems:
- Sensitivity
- Rep.-rate
PVDF foil, thickness $d$ (no absorption bands for $\lambda>50$ $\mu$m)
refractive index $n=1.6\pm0.15$

Front (area) resistance $s$

Rear (area) resistance $r$

$R(s, r, n, d, \lambda)$

$T(s, r, n, d, \lambda)$

$A(s, r, n, d, \lambda)$

Modelling

(Maxwell Equation)
Two metallic coatings ($s$ and $r$) and a pyroelectric carrier

In contrast to organic coatings:
Metallic film thickness about 100 nm → high sensitivity $\mu$W...mW
→ high rep. rate $\ldots$500 Hz!!
Comparison Modelling and Experiments

Sensors with high absorption between 70 bis 80 µm

Absorptivity vs. wavelength  \( A=1-T-R \) from TDS Measurements

Standard THz Detectors

Best parameters

Normalized Sensitivity for a metallic THz Absorber

Fourier Transform Spectrometer
Heat capacity of the sensor is proportional to film thickness. Reduction of heat capacity increases the sensor temperature.

- Thinner sensor foil
- Higher sensitivity

12 µm → 4.5 µm
Two Trapdetectors at 3 wavelengths (1.04 THz, 1.4 THz and 2.52 THz)

<table>
<thead>
<tr>
<th>Wellenlänge/THz</th>
<th>Sens. C1 in V/W</th>
<th>SensorC2/ V/W</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,52</td>
<td>251</td>
<td>256</td>
</tr>
<tr>
<td>1,4</td>
<td>243</td>
<td>247</td>
</tr>
<tr>
<td>1,04</td>
<td>252</td>
<td></td>
</tr>
<tr>
<td>Mittelw. Abweichung</td>
<td>248 +/- 4 V/W ( +/- 2%)</td>
<td>252 +/- 5 V/W ( +/- 2%)</td>
</tr>
</tbody>
</table>
Time behaviour:
- Pyroelectric effect is very fast
- Heat conduction from coating to foil is fast

Limiting parameters:
- Preamplifier (noise) \( \rightarrow P > 500 \text{ nW} \)
- Thermal time constant \( \rightarrow \text{rep.-rate} > 10 \text{ Hz} / 25 \text{ Hz} \)
- Max. power density: 20 mW/cm²

Rep.-rate 10, 15 and 20 Hz
preampl 10\(^{10}\) V/A, \( f=25 \text{ Hz} \)

Si=6000 V/W

Noise 4 mV (25 Hz)
NEP=4 mV/(6000 V/W)=0.67 \( \mu \text{W} \)
Energy detection

R*C >> Thermal time constant >> pulse duration

U ~ Q ~ ΔT ~ E

\[ S_E = 150 \text{ V/J} \]

Voltage preamplifier. V = 10x, 100 x and 1000 x

Sensitivities up to 2000 V/J are possible \( 100 \text{ nJ} < E < \text{ mJ} \)
Power measurement of a TDS-system together with colleagues from HHI

\[ P_{\text{max}} = 0.1 \text{ mW} \]

- Time-Domain-Spectrometer of Fraunhofer
- Heinrich-Hertz Institute

Summary
Wavelength 50 µm…>1mm
- Diameter 10…30 mm
- Detection range: <1 µW…>10 mW/cm²
- 100 nJ<E< mJ
- Chopper frequency: 10Hz…500Hz
Thank you !!

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