Terahertz Microstrip Leaky-Wave Antenna for WR1.0 Band

UNIVERSITÄT DUISBURG ESSEN

Open-Minded

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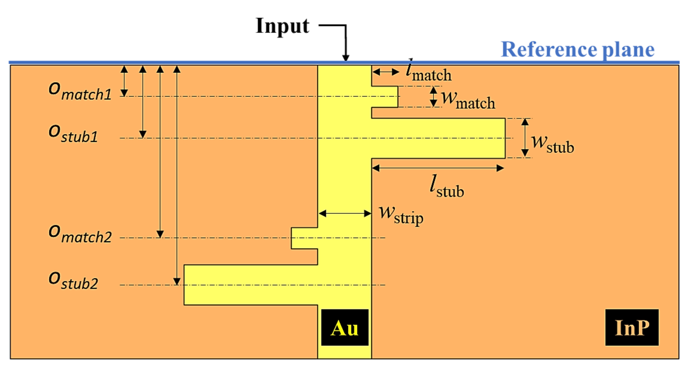
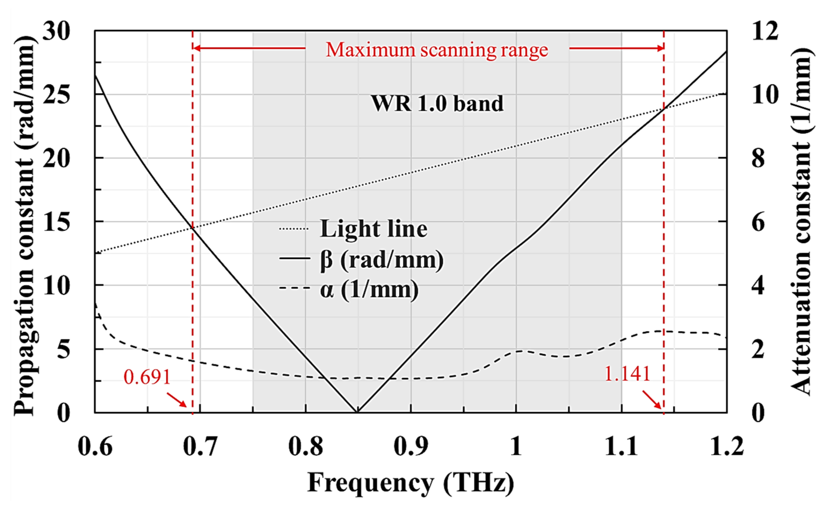
Abstract

This paper presents the first THz periodic **microstrip LWA** with a suppressed open stopband for **WR1.0 band** between 0.75 and 1.1 THz for future communication applications. The designed 20-unit cell LWA on 20 µm InP substrate has been simulated in CST. For the whole domain, the **return loss** and the **insertion loss** are **17 dB** and **20 dB**, respectively. Furthermore, the LWA has a maximum total efficiency of 76.12% at 0.77 THz. In addition, the beam steering capabilities show a **scanning range of 92°** in the WR1.0 band when sweeping the frequency from 0.75 THz (-35°) to 1.1 THz (57°). On the other hand, the **realized gain** varies between **12.6 and 14.1 dBi** at 0.75 and 1.0 THz, respectively.

Chip Design

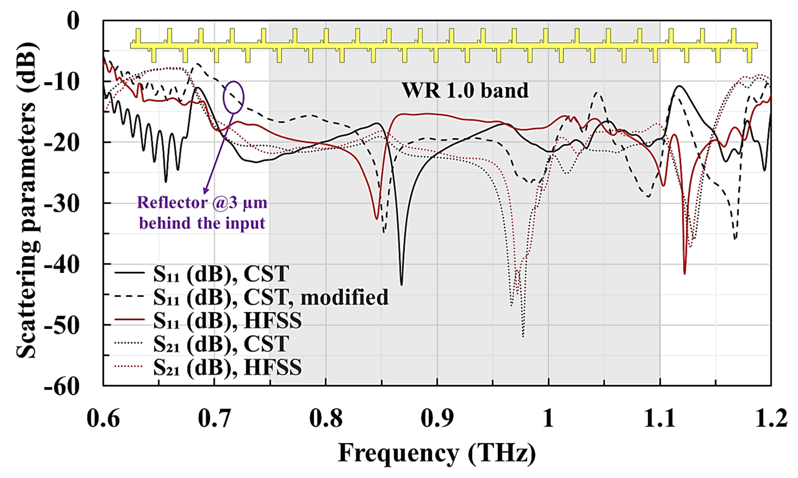


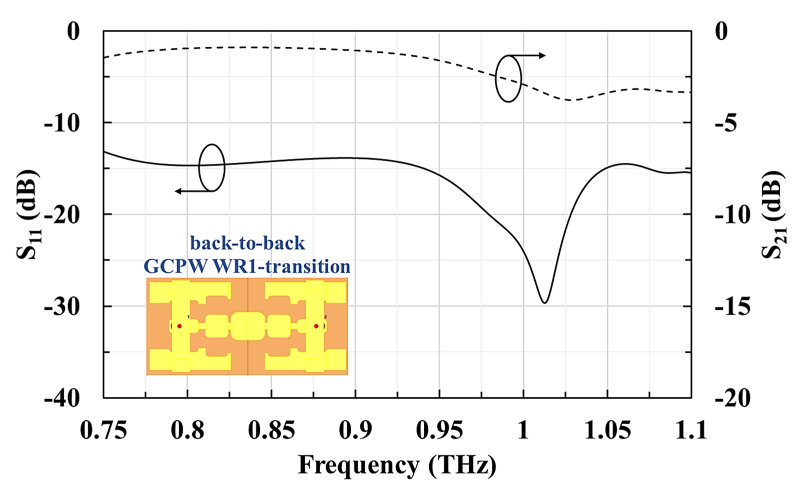
Symbol	Description	Value (µm)	Symbol	Description	Value (µm)
w_{strip}	The width of main strip	20.0	l_{stub}	The length of main stub[a]	50.0
l_{strip}, (p)	The length of main strip (antenna period)	110.0	O_{match1}	Offset to reference plane at input	12.0
w_{match}	The width of matching stub[a]	8.0	O_{stub1}	Offset to reference plane at input	27.5
l_{match}	The length of matching stub[a]	10.0	O_{match2}	Offset to reference plane at input	65
w_{stub}	The width of main stub[a]	15.0	O_{stub2}	Offset to reference plane at input	82.5



Single unit cell

- Dual-matching stub to eleminate open stopband issue [1, 2]
- Substrate thickness 20 µm ($< \lambda_g/4$)
- Wide-angle scanning, $p_{\text{unit\_cell}} \approx \lambda_g$
  - $\lambda_g = \frac{c_0}{f\sqrt{\varepsilon_{\text{eff}}}} = 112.6\ \mu\text{m}$
  - $\varepsilon_{\text{eff}} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2} \cdot \left[\frac{1}{\sqrt{1+\frac{12 \cdot h_{\text{substrate}}}{w_{\text{strip}}}}}\right] = 8.28$
- Broadside expected at 0.848 THz
- Scanning capability of 450 GHz





LWA Structure

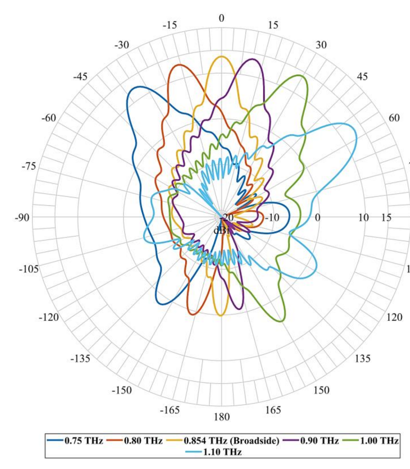
- Optimized for WR1.0 band
- Concatination of 20-unit cells, total length of 2.2 mm
- Grounded InP-substrate of 20 µm thin

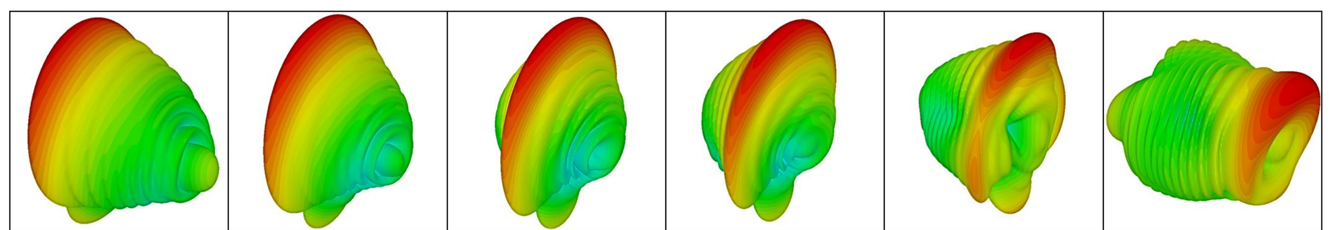
Grounded CPW Transition

- Zero backshort design
- on-chip charachterization
- monollithic integration with state-of-art MUTC-PD [4]

Beam Steering Capabilities

- From backward -35° to frontward 57° for frequency sweeping from 0.75 THz to 1.1 THz
- Elevation zero-reference angle at broadside of 0.854 THz
- Total efficiency decreases with frequency: 76.12% at 0.77 THz and 61% at 1.1 THz





Frequency	0.75 THz	0.8 THz	0.854 THz	0.9 THz	1 THz	1.1 THz
Realized gain	12.6 dBi	13.2 dBi	13.6 dBi	13.7 dBi	14.1 dBi	13.3 dBi
Beam direction	-35°	-16°	0°	11°	30°	57°
3dB beamwidth	13.2°	10.7°	9.3°	9.8°	10.3°	14.2°
SLL	-10.7 dB	-12.2 dB	-10.9 dB	-13.7 dB	-9.1 dB	-11.1 dB

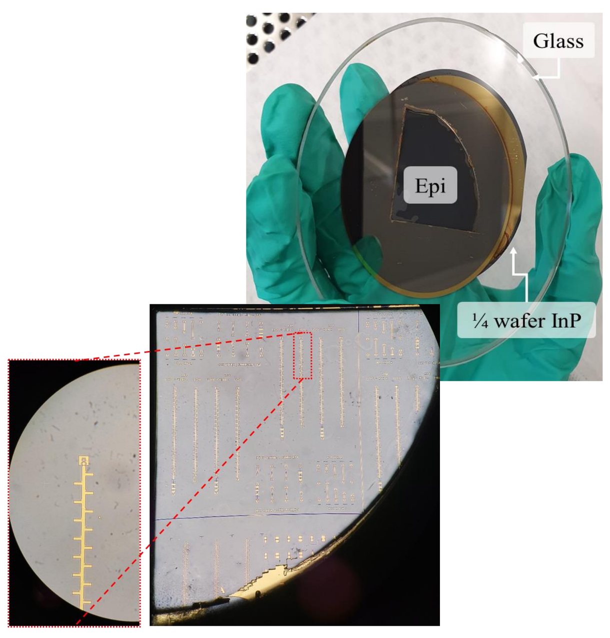
Fabrication

Concept

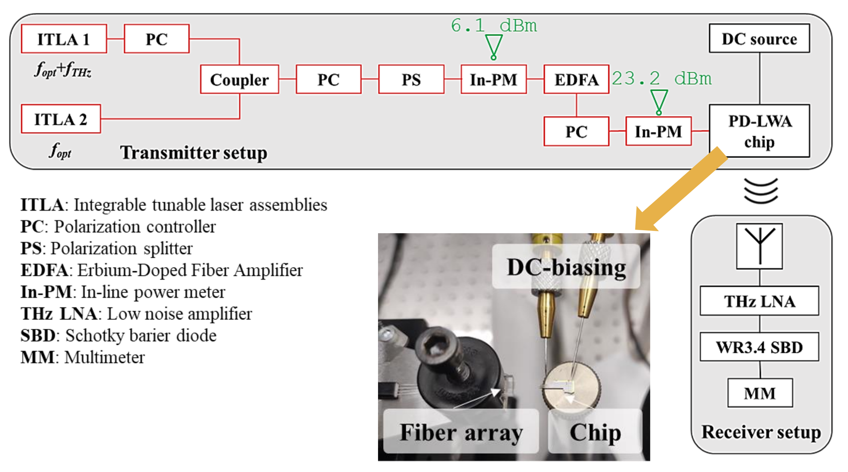
- Substrate transfer technology using thermocompression bonding (TCB) [3]

Proof-of-Concept

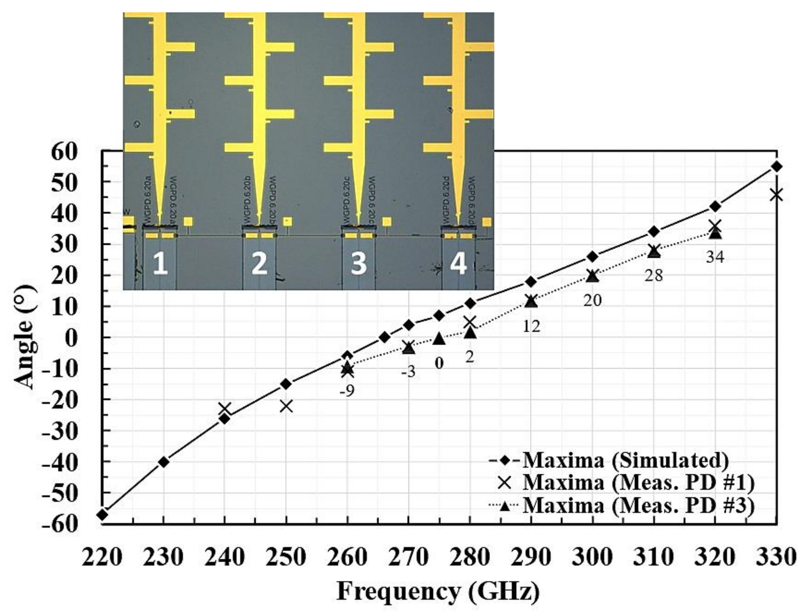
- WR3.4 frequency band (220 to 330 GHz)
- Substrate thickness 50 µm



Experimental Results



System setup and beam steering characterization at WR3.4 band



Literatures:

[1] S. Paulotto *et al.*, "A novel technique for open-stopband suppression in 1-D periodic printed leaky-wave antennas," *IEEE Trans. Antennas Propag.*, vol. 57, no. 7, pp. 1894-1906, 2009.

[2] T. Haddad *et al.*, "Suppressing Open Stopband for Terahertz Periodic Microstrip Leaky-wave Antennas," in *17th European Conference on Antennas and Propagation (EuCAP)*, 2023.

[3] P. Lu *et al.*, "InP-based THz beam steering leaky-wave antenna," *IEEE Trans. Terahertz Sci. Technol.*, vol. 11, no. 2, pp. 218-230, 2020.

[4] M. Grzeslo *et al.*, "High saturation photocurrent THz waveguide-type MUTC-photodiodes reaching mW output power within the WR3.4 band," *Opt. Express.*, vol. 31, no. 4, pp. 6484-6498, 2023.

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DAAD Deutscher Akademischer Austauschdienst German Academic Exchange Service

TERAOPTICS

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