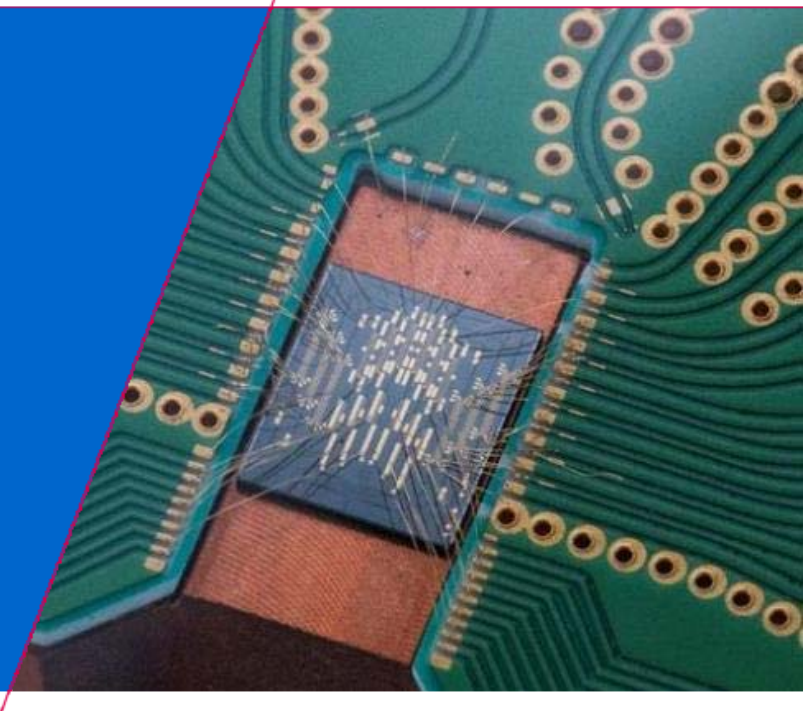
OP Zuid WP3
November 7, 2016



Institute for Photonic Integration
Materials · Devices · Systems

TU/e Technische Universiteit Eindhoven University of Technology

Where innovation starts

Agenda

- **PART I**
  - **WP3.1 BB Design**
  - **WP3.3 BB Characterization**
  - **WP3.5 Demonstrator Design (if required)**
  - **WP3.2 PDK Content**
  -
- **PART II**
  - **WP3.4 Design Environment**

WP 3.1 - BB Design

TABLE 2				M3	M6	M9	M12	M15	M18	M21	M24	M27	M30	M33	M36
List of Building Blocks	**Design lead**	**Contact person**	**Comments**	**Year 1**				**Year 2**				**Year 3**			
High-precision filter	Bright	Ronald													
Tunable, low linewidth laser	Bright	Ronald													
(low-loss passive WG)	Bright	Ronald													
High-speed modulator (iteration 28G, 56G, 128G)	TUe	Weiming	2 types of design, CPW and capacitively loaded CPS	iteration 1				iteration 2				iteration 3			
High-speed RF line	TUe	Weiming	1st iteration using 2 layer metal routing, 2nd iteration using thick planarization + selective opening		Iteration 1					Iteratio n 2					
Spot-size converter	TUe	Weiming	Lateral SSC concept												

WP 3.1 - BB Design – Processing Requirements

Design parameters			Process parameters (required)													
			Task 4.1					Task 4.2					Task 4.3			
Building blocks	Figures of merit	Target values	Epi. layer thickness variation	Epi. index variation	QW E-O coefficient	P-cladding doping	Contact resistance (Ω cm^2)	Separation ridge-metal min. (µm)	WG width min. (µm)	WG width variation	Side-wall roughness (nm)	Etch depth variation	Polymer thickness (µm)	Polymer thickness variation	Metal thickness (µm)
High-speed modulator	EO bandwidth	20, 40, 80 GHz in stages			(x) (BW Vπ trade-off)		1E-06	3	1	x					> 1 (skin effect)
	Vπ value	~2 V	x (QW design)		(x) (BW Vπ trade-off)										
	Insertion Loss	< 6 dB									x	x			
High-speed RF-line	Bandwidth (3 dB)	> 40 GHz				x (local Zn)		x					> 5 µm	x	> 1 (skin effect)
	Impedance	50 Ω											x	x	(x)
Spot-size converter	Coupling loss	< 1 dB	x	x					x (0.5 µm)	x	x				
	Spot size	4x4 um^2 or 10x10 um^2													
High-precision filter	Wavelength accuracy	< 1 pm	x						x	x					
	Insertion loss	< 3 dB ?									x				
	Cross-talk	< -40 dB										x			
Low-linewidth, tunable	Linewidth	~100, 10, 1 kHz stages				x (local Zn)				x	x				
	Tunable range	> 30 nm													
	Output power	> 0 dBm		x			x				x				
Low-loss WGs	Propagation loss	< 1 dB/cm	x	x		x (local Zn)			x	x	x	x			

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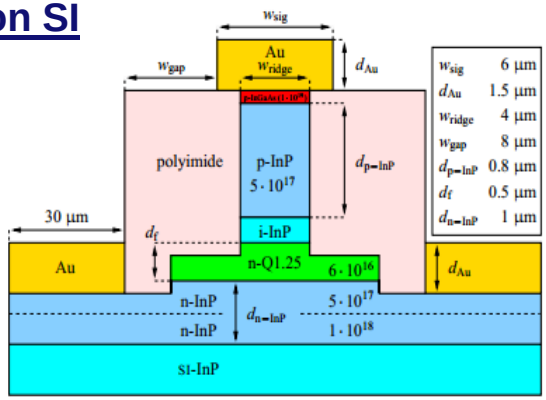
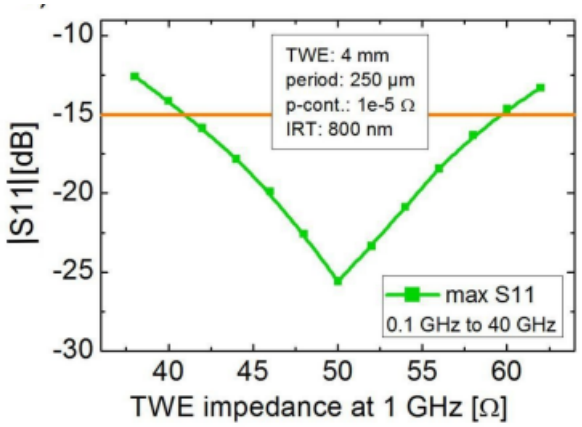
Modulator

CPW on SI

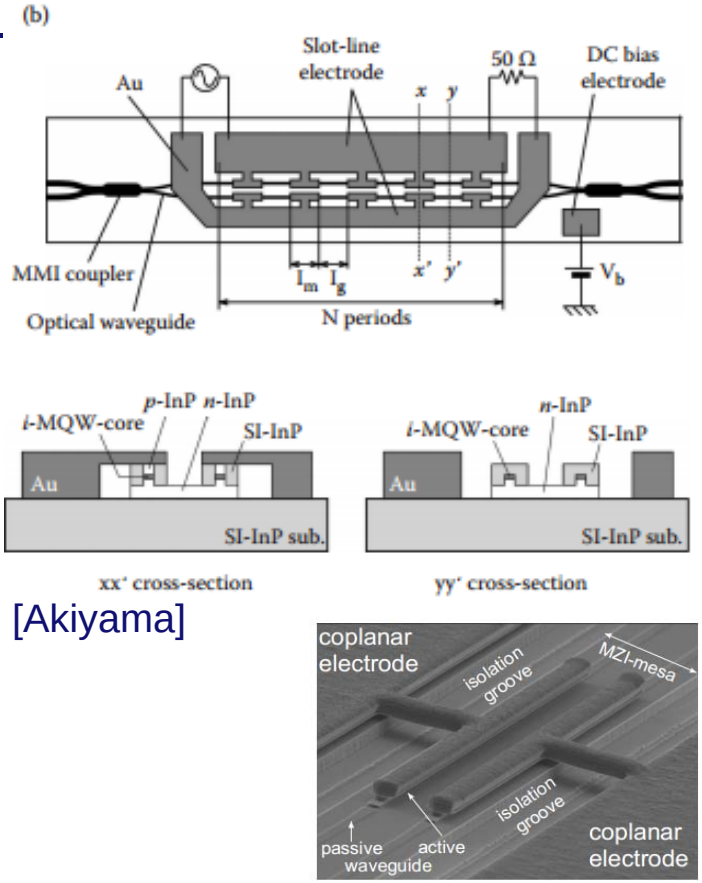


[den Besten]



[Haitao]

CL-TWE on SI

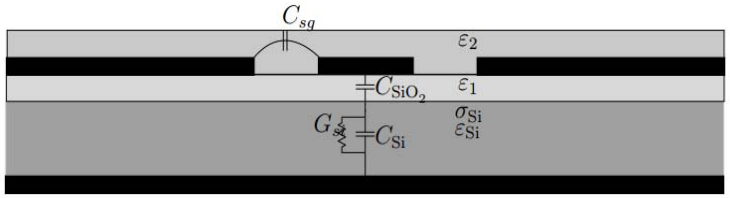


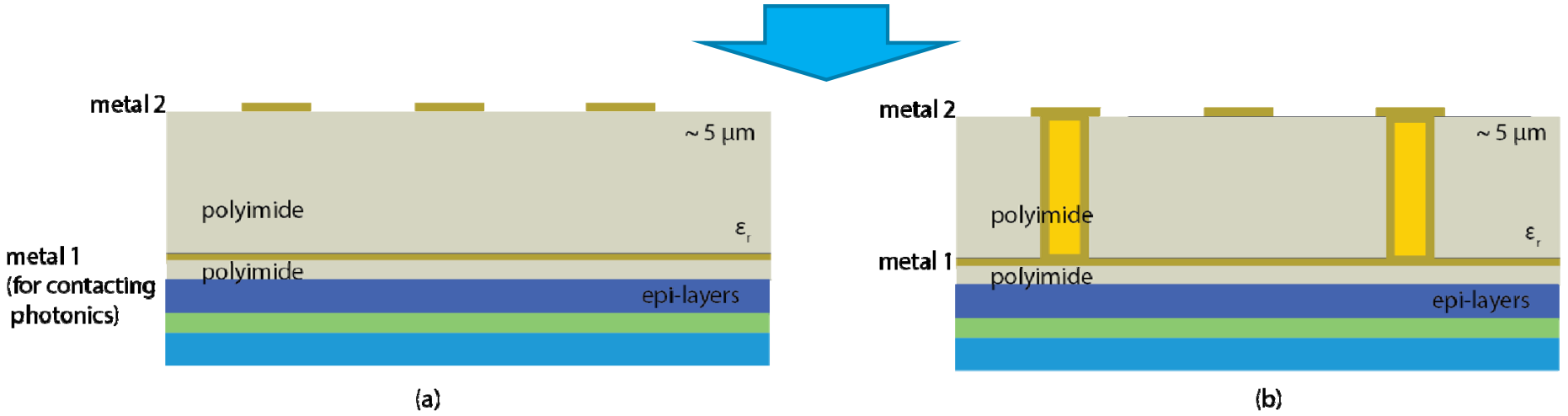
[Akiyama]

[Haitao]

RF Interconnects

Substrate losses/epi layer losses





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Spot Size Converter

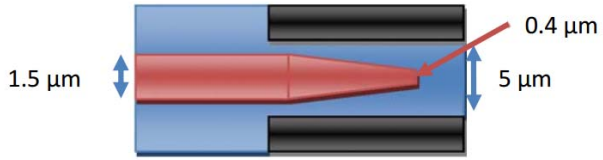


Figure 62: Laterally tapered SSC defined as deeply etched waveguide

[PARADIGM]

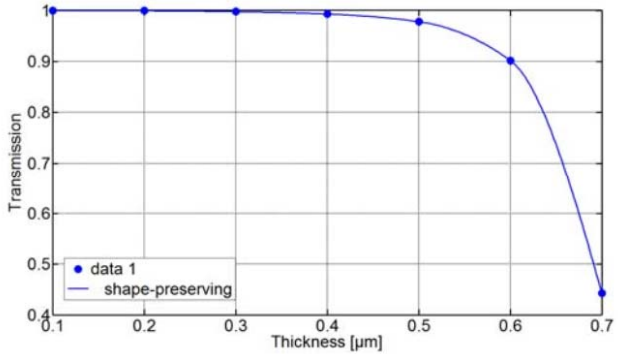
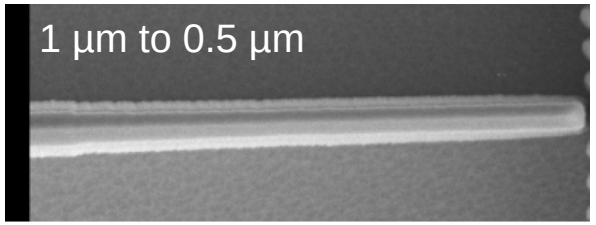


Figure 63: Transmission through the IMW on impact with deep waveguides of different width on top

[PARADIGM]

Using DUV or stepper



[PARADIGM]

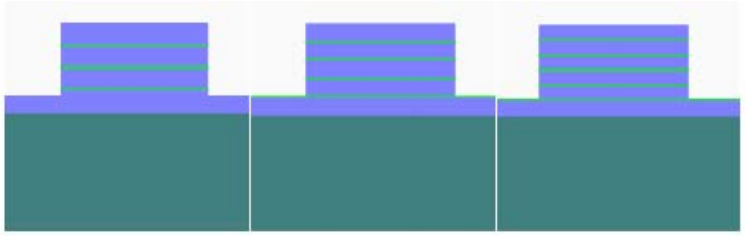


Figure 65: Diluted Waveguide approach for SI-Substrates based on periodically spaced quaternary layers

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WP 3.3 – BB Characterization

WP 3.3	BB Characterization						Year 1				Year 2				Year 3			
#	M or R title	Description	items	Responsible	person	involved												
R0	Design of Standard MPW BB test cell	Test cell(s) incorporates ALL necessary structures to measure BB FoM and gain statistically relevant data.	several	SMART	Rui	TU/e, Bright												
M0	Report on standard MPW BB cell results	Meausrement results of basic BB from standard MPW test cell	1x	SMART	Rui	TU/e, Bright												
R1	Design of composite BB test cell	test structures for measuring FoM of composite BBs	1x	TU/e	Weiming	Smart, Bright, Effect												
M1	Report on composite test cell results	Meausrement results of composite BB from MPW test cell	1x	TU/e	Weiming	Smart, Bright												

WP 3.3 – BB Characterization

a. **SOA**
   - Spectral gain
   - Saturation output power
   - Carrier recombination time

b. **EOPM**
   - Loss/cm
   - Vpi x L
   - EOBW x L
   - Nonlinearity

c. **Shallow/Deep WG + tapered WG**
   - Losses

d. **AWG**
   - Insertion loss
   - Channel crosstalk

e. **Photodetector**
   - EOBW
   - Dark current
   - Responsivity
   - Max input power

f. **MIRs/MMIs**
   - Losses
   - Reflectivity/Transmittivity

g. **Saturable Absorber**
   - Absorption spectra
   - Recovery time
   - Saturation power

h. **Current Injection tuning**
   - Efficiency
   - Bandwidth

i. **Electrical Isolation**
   - Isolation resistance/L

j. **RF metal**
   - Contact resistance to InGaAs, to n-InP
   - Sheet resistance p-InP, n-InP, InGaAs, i-InP, Q-layer, SI substrate, polyimide

WP3.5 Demonstrator Design (if required)

Transmitter

- 400 GbE?
- Advanced modulation formats
- Parallel transmitter

Sensor/tunable laser/readout

- Circuit block diagram

WP3.2 PDK Content

WP 3.2	PDK Content						Year 1				Year 2				Year 3			
#	M or R title	Description	items	Responsible														
M0	State of the PDK	Report on current state of PDK and list issues to be solved	1x	SMART	Rui	TU/e, Bright												
M1	Definition of basic BB figure of merits	list all relevant FoM to be measured for basic BB, feed-in from survey WP1	1x	TU/e	Weiming	Smart, Bright												
M2	Definition of composite BB FoM	list all relevant FoM to be measured for composite BB, feed-in from survey WP1	several	TU/e	Weiming	Smart, Bright												
R0	Definition of measurement procedures	Measurement procedures of both basic and composite BBs, related to test cell design	several	TU/e	Weiming	Smart, Bright, Effect												
R1	PDK upgrade with new advanced BB	include the BBs from WP3.1 into PDK with measurement results and figure of merit. Creation of library CBBs	several	SMART	Rui	Bright, Smart, Phoenix												
R2	Compact Models	Describe workflow and concept of compact models	1x	Phoenix	Marcel	Bright, Smart, TU/e												

Effort table WP3

Man hours

WP #	Bright	Smart	Phoenix	Effect	Lionix	TU/e	Technobis
WP 3.1	3500	400		500	200	4000	300
WP 3.2	1000	640	1840	500		2000	
WP 3.3		1500		300		1500	
WP 3.4	3200	640	3000			1500	
WP 3.5				1452	200	250	300
sum	**7700**	**3180**	**4840**	**2752**	**400**	**9250**	**600**

Agenda

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- **PART II**
  - **WP3.4 Design Environment**

WP3.4 Design Environment - not finalized yet

WP 3.4	Design Enviroment				
number	M or R title	Description	items	Responsible	
M0	Status of design flow	Outline presenting design workflow and procedures, identifying points of improvement	1x	Phoenix	Marcel
M1	Design flow improvement concept	present the concept of the improvements to be worked on	1x	Phoenix	Marcel
R0	Standardized templates for establishing compact models	Detail the concept and requirements for compact models for BBs	1x	Phoenix	Marcel
R1	Advancement of DRC functionality	improving on present DRC capabilities in design flow cycle	1x	Bright	Ronald
R2	Improvement of mask level software capability	Improving tools that work on mask and layout level to facilitate design procedure	1x	Bright	Ronald
M2	Convergence of design enviroment	Achieving closer interplay between design tools and enviroments	1x	Phoenix	Marcel