Contributions and planning from TU/e

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29/08/2017

General planning

Technische Universiteit Eindhoven University of Technology

- 5 parallel tasks defined

Tasks	Milestones / Deliverables		Responsible	Due date
T 0. General planning	M 0.1	Specific tasks and milestones defined; WP started	Longfei	Dec-16
	M 0.2	Quantifiable criteria for each milestone defined	Longfei	Mar-17
T 1. Al-MQW based modulators	M 1.1	Designed MQW characterized, shallow-etch modulators demonstrated	Longfei	Dec-17
	M 1.2	Etching and passivation processes developed: ready for MPW validation	Longfei	Jun-18
	M 1.3	Modulator validated in MPW: ready for release	Smart	Mar-19
	D 1.4	Report on process optimization and insights for Al-based SOA and 100 Gbps modulators	Longfei	Jun-19
T 2. Zn-diffusion based A/P integration	M 2.1	Zn-diffusion time determined: ready for joint MPW validation	Rene	Jun-17
	M 2.2	Zn-diffusion process validated in joint MPW: ready for transfer to Smart	Rene	Mar-18
	M 2.3	Zn-diffusion process transferred and validated in MPW: ready for release	Smart	Dec-18
	D 2.4	Report on process integration and device characterization	Rene, Longfei	Dec-18
T 3. Thick insulation and RF lines	M 3.1	BCB insulation and metal plating tested: ready for joint MPW validation	Tjibbe	Sep-17
	M 3.2	Process validated in joint MPW (post-processing): ready for transfer	Tjibbe	Mar-18
	M 3.3	Process transferred and validated in MPW: ready for release	Smart	Sep-18
	D 3.4	Report on process integration, insights for 100 Gbps RF lines, and for multi-layer routing	Tjibbe, Longfei	Dec-18
T 4. DUV lithography and etching optimization	M 4.1	DUV lithography introduced to MPW	Smart	Jun-17
	M 4.2	Etching process optimized, ready for transfer to MPW	Longfei	Mar-18
	M 4.3	DUV lithography introduced to Triplex platform	Lionix	Jan-19
	D 4.4	Report on process integration (lithography and etching) in MPW	Smart	Jan-19
T 5. Stepper lithography integration	M 5.1	Process developed for AZ and MaN based lithography	Robert	Aug-17
	M 5.2	Overlay tested and optimized	Robert	Jan-18
	M 5.3	Process introduced to Smart MPW	Smart	Sep-18
	D 5.4	Report on process integration, insights for fabricating new BBs	Robert, Longfei	Dec-18

General planning

- Criteria quantified for each specification

Milestone	Item/spec	Target value/range	Test sample	Characterization
M 1.1	**Designed MQW characterized, shallow-etch modulators demonstrated**			
	Reactor upgrade and calibration		dummy wafers (5-10)	PL (5 spots)
	Bandgap MQW	1400 ± 50 nm		
	VπL	< 5 Vmm	shallow-etch mods in 2 MPW runs	E-O, >5 per wafer; >50 with auto test
	Insertion loss	< 5 dB		
	Bandwidth	> 20 GHz		
M 1.2	**Etching and passivation processes developed: ready for MPW validation**			
	Etch-stop control	± 50 nm	Deep-etch WGs (>10 wafers for fine tuning)	Tencor (> 10 spots)
	Side-wall slope	< 3 °		CD-SEM; X-SEM
	Oxidation depth	< 200 nm		X-SEM
	Carrier life time	t.b.d.		µPL
M 1.3	**Modulator validated in MPW: ready for release**			
	Regrowth/butt-joint reflection	< -50 dB	3 iterations of MPW validation	Customized test cells
	Bandwidth	> 40 GHz (56 Gbps)		
	Insertion loss	< 5 dB		
	Leakage current	< 1 µA		
	Spec variations in other components	< 10%		Standard test cells

Milestone	Item/spec	Target value/range	Test sample	Characterization
M 2.1	**Zn-diffusion time determined: ready for joint MPW validation**			
	Diffusion reproduced in new reactor		dummy wafers	CV
	Diffusion rate vs P, T	t.b.d.	dies (epi: InP, InGaAs, MPW)	CV
	Active carrier ratio	> 90%		RTA+CV, SIMS
	Diffusion depth control	± 0.1 µm	MPW wafers (3)	CV (>5 spots)
M 2.2	**Zn-diffusion process validated in joint MPW: ready for transfer to Smart**			
	Diffusion in selective areas		dummy wafer with markers	microscope
	Lateral diffusion under SiNx mask	< 1 µm		X-SEM
	WG loss	< 0.5 dB/cm	3 iterations of MPW validation	Standard test cells
	Laser and phase shifter spec deviation w.r.t. typical values	< 10%		
M 2.3	**Zn-diffusion process transferred and validated in MPW: ready for release**			
	Same as M 2.2			

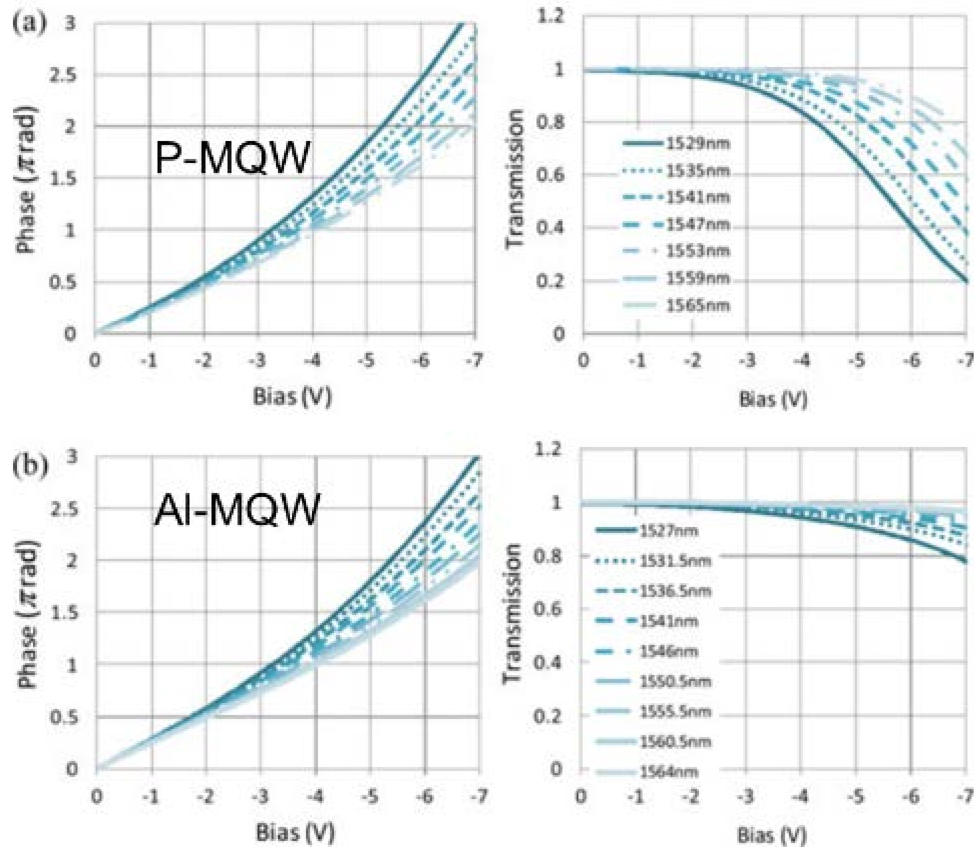
Milestone	Item/spec	Target value/range	Test sample	Characterization
M 3.1	**BCB insulation and metal plating tested: ready for joint MPW validation**			
	BCB thickness; uniformity	> 5 µm; ± 0.5 µm	MPW processed wafers (2-3)	reflectometry
	BCB edge bead	< 5 mm		
	Metal thickness; uniformity	> 2 µm; ± 0.2 µm	dummy wafers	Tencor
	Metal-BCB adhesion tested (tape, wire-bonding)			microscope
M 3.2	**Process validated in joint MPW (post-processing): ready for transfer**			
	Resistance from contact to RF line	< 1 Ω	2 iterations of MPW validation	Customized test cells
	RF line bandwidth	> 40 GHz		
	Max current	> 10 mA		
	Other components specs deviation w.r.t. typical values	< 10%		Standard test cells
M 3.3	**Process transferred and validated in MPW: ready for release**			
	Same as M 3.2			

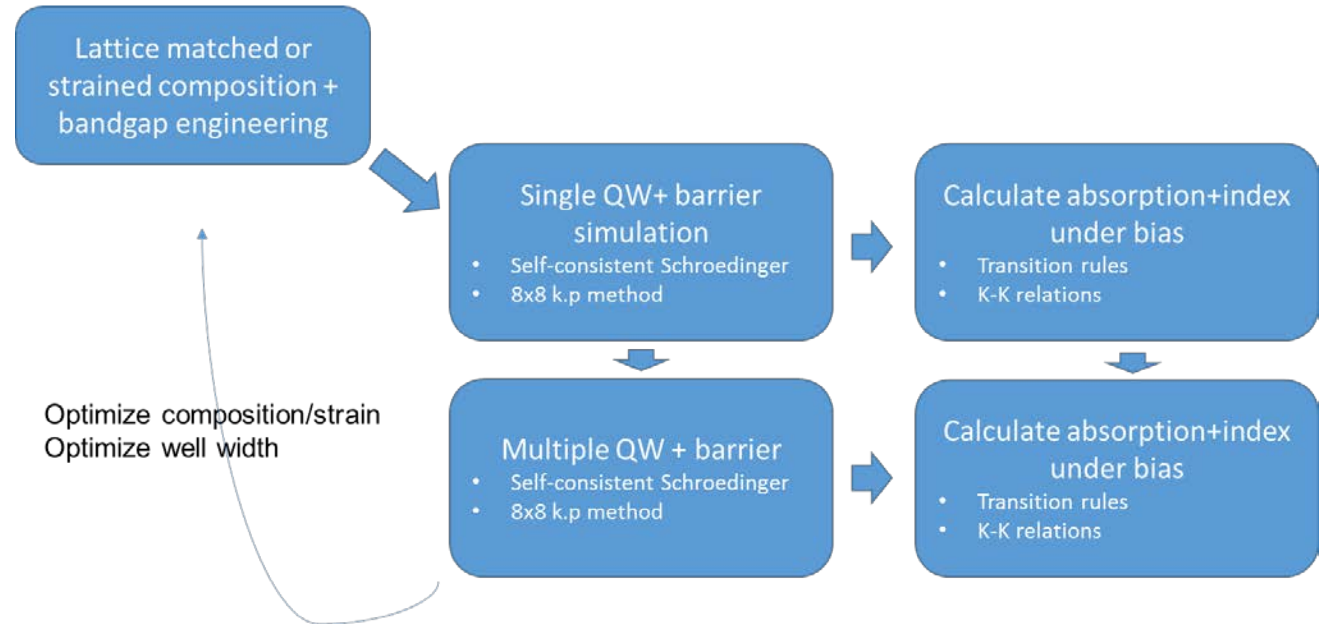
Milestone	Item/spec	Target value/range	Test sample	Characterization
M 4.1	**DUV lithography introduced to MPW**			
	Definition of A/P areas, gratings, WGs		2-3 iterations of MPW validation	CD-SEM test cells
	CD for widths and gaps determined			
	CD optimization	50 nm (gaps in AWG)		
M 4.2	**Etching process optimized, ready for transfer to MPW**			
	Etch-stop control	± 50 nm	Deep-etch WGs (> 20 wafers for fine tuning)	Tencor (>10 spots)
	side-wall slope	2-3° (CH4-H2); 0.5-1° (Cl2)		CD-SEM; X-SEM
	WG loss	< 0.5 dB/cm (undoped wafers)		>10 per wafer; >100 with auto test
M 4.3	**DUV lithography introduced to Triplex platform**			
	Unknown			

Milestone	Item/spec	Target value/range	Test sample	Characterization
M 5.1	**Process developed for AZ and MaN based lithography**			
	Focus-energy matrix measured		dummy wafers	CD-SEM
	Min widths	2 µm		
	CD uniformity	< 5%		
	Negative slope formed for metal lift-off			X-SEM
M 5.2	**Overlay tested and optimized**			
	DUV marker visibility check		dummy wafers	CD-SEM
	Alignment accuracy	< 0.3 µm		
M 5.3	**Process introduced to Smart MPW**			
	Flow and design manual updated		3 iterations of MPW validation	CD-SEM test cells
	Alignment accuracy	< 0.3 µm		
	New BB designs demonstrated with improved alignment accuracy			Customized test cells

Task 1: Al-MQW based modulators

- Design stage for Al-MQW (meanwhile experiments for P-MQW)





Task 2: Zn-diffusion integration

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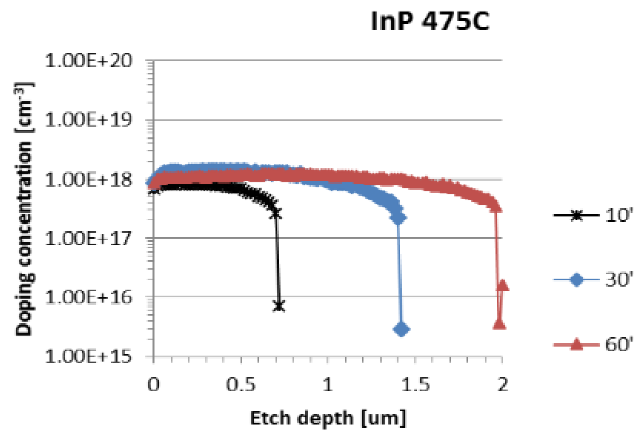
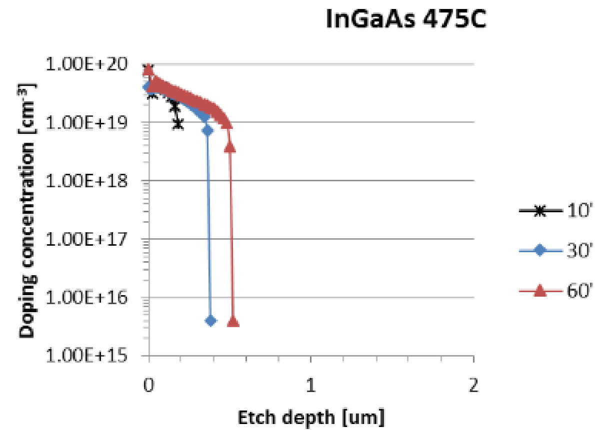
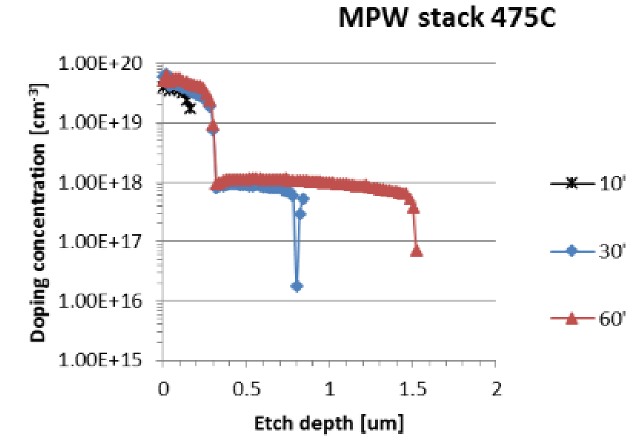
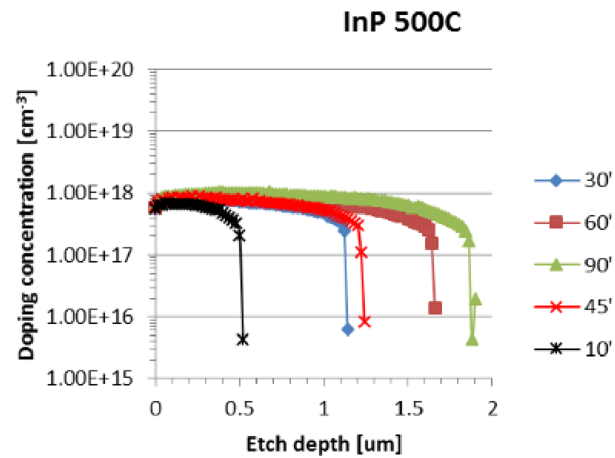
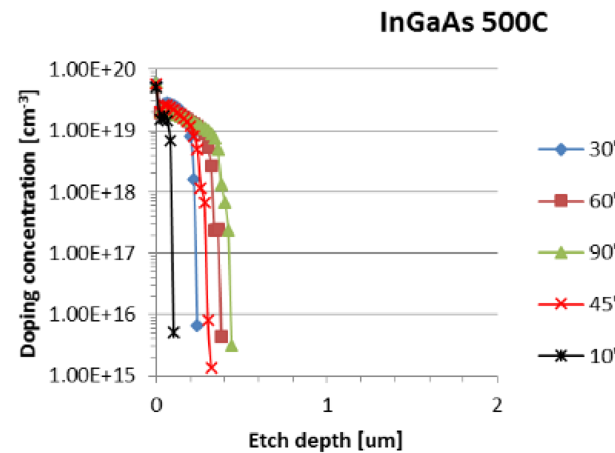
- Diffusion calibration and measurements

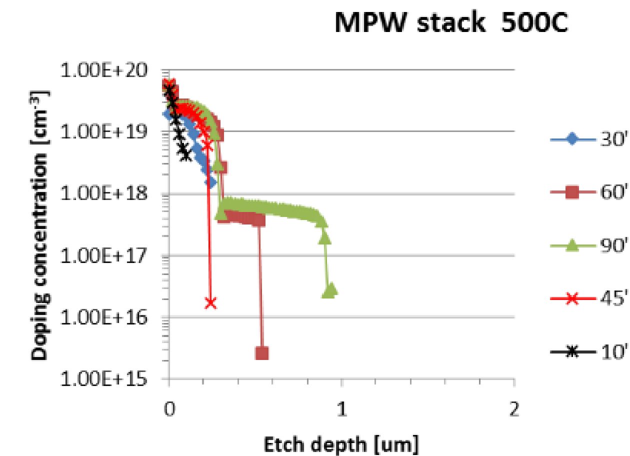






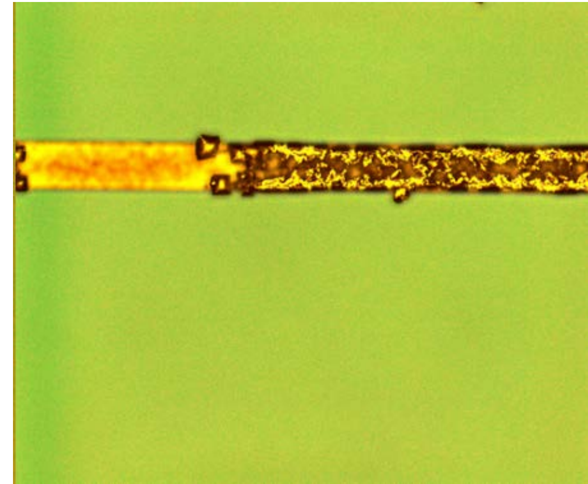


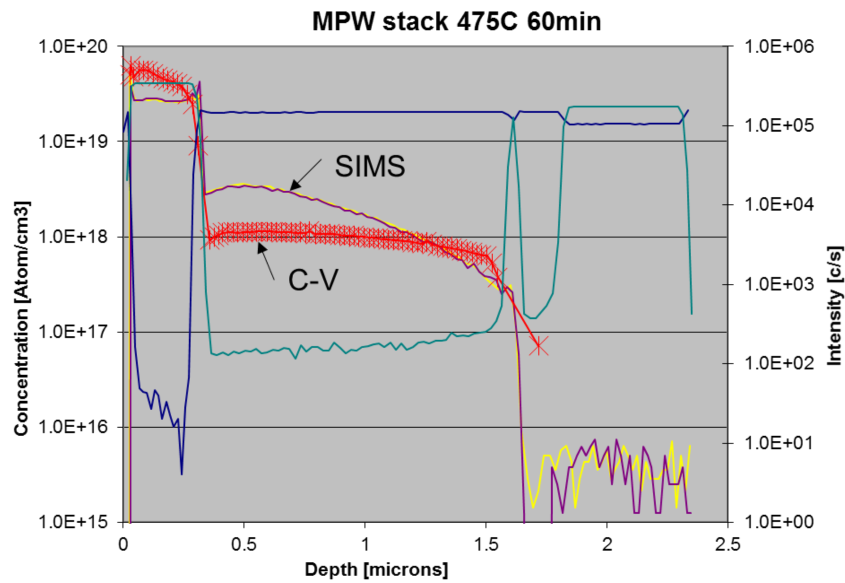


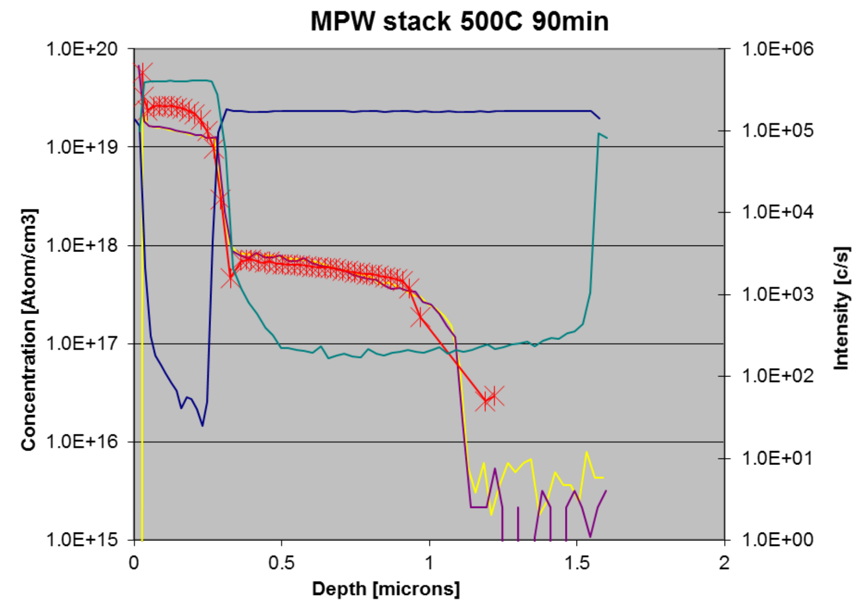


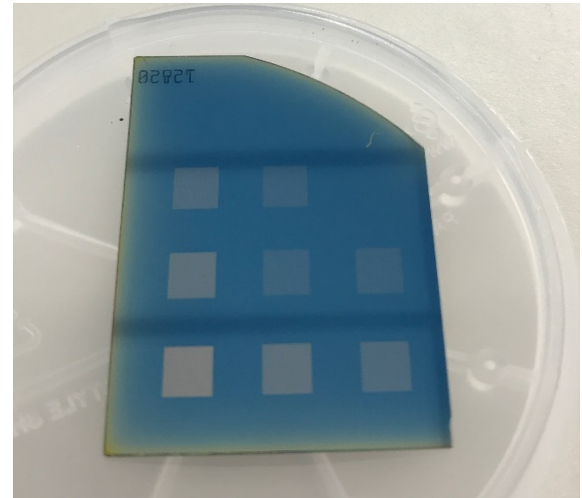
Task 2: Zn-diffusion integration

- Zn interstitials and crystal formation at 475C
- Mask transmission dependent diffusion rate

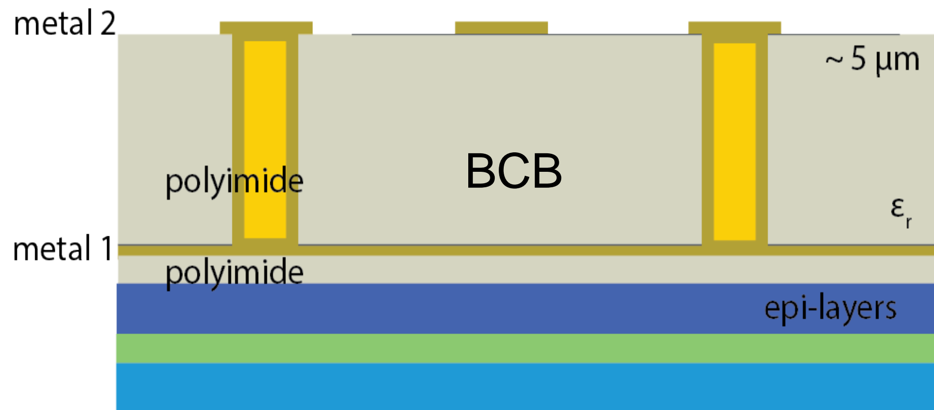


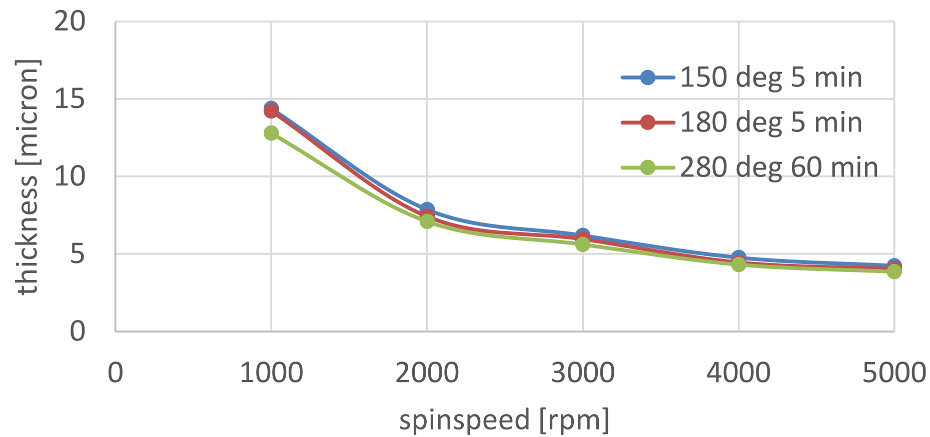




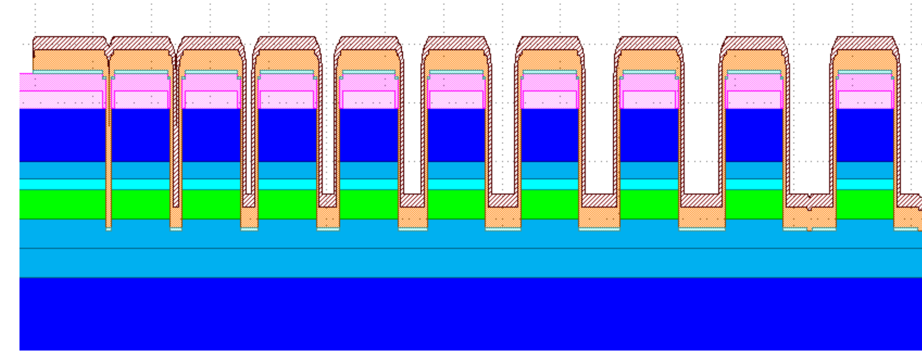


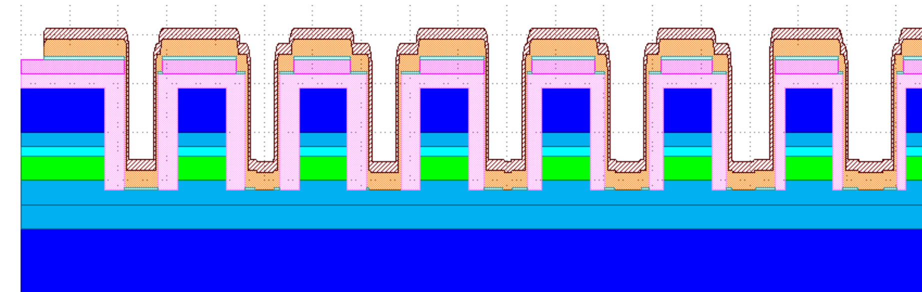
Task 3: Thick insulation and RF lines





Development on BCB done: spin, lithography, reflow, etching, etc



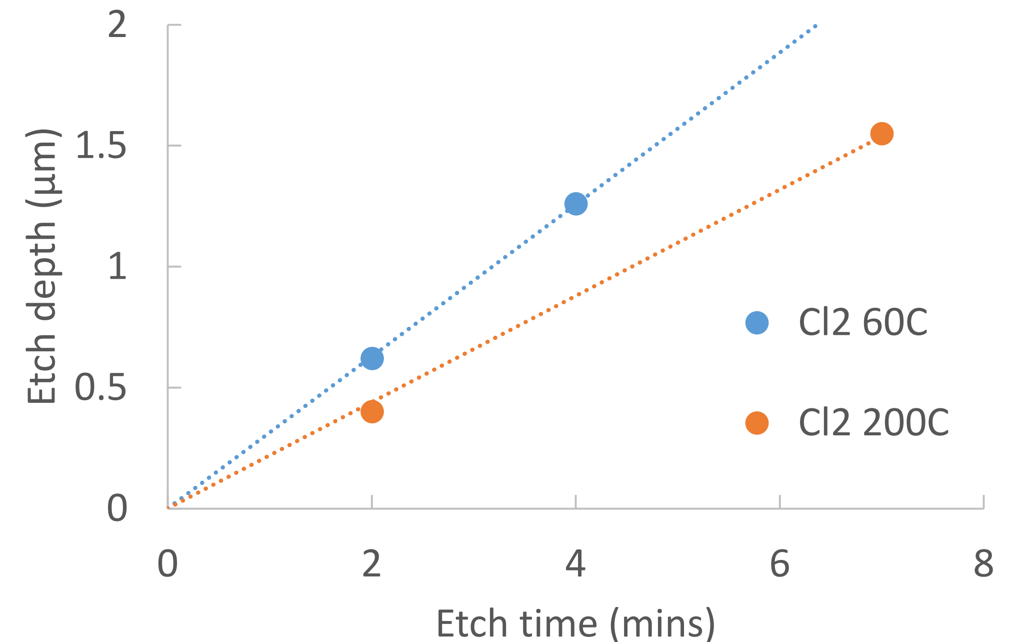


Development on metals underway:
Plating samples (SP19) inspection;
Metal on BCB adhesion test.

Task 4: DUV lithography and etching

- DUV lithography has been introduced to MPW SP20 (June 2017, milestone)
- Optimization of the subsequent etching process
  - Original recipe CH_4-H_2 optimized at Smart
  - New recipe CH_4-H_2-Cl_2 tested at TU/e

Samples (InP bars)	Recipes	Etch rate (nm/min)	
		InP	SiNx
#1 reference	CH4-H2 @60C	78	2.4
#2 test	CH4-H2-**Cl2** @60C	360	50
#3 test	CH4-H2-**Cl2** @200C	250	30
#4 reference	CH4-H2 @60C	72	2



Task 4: DUV lithography and etching

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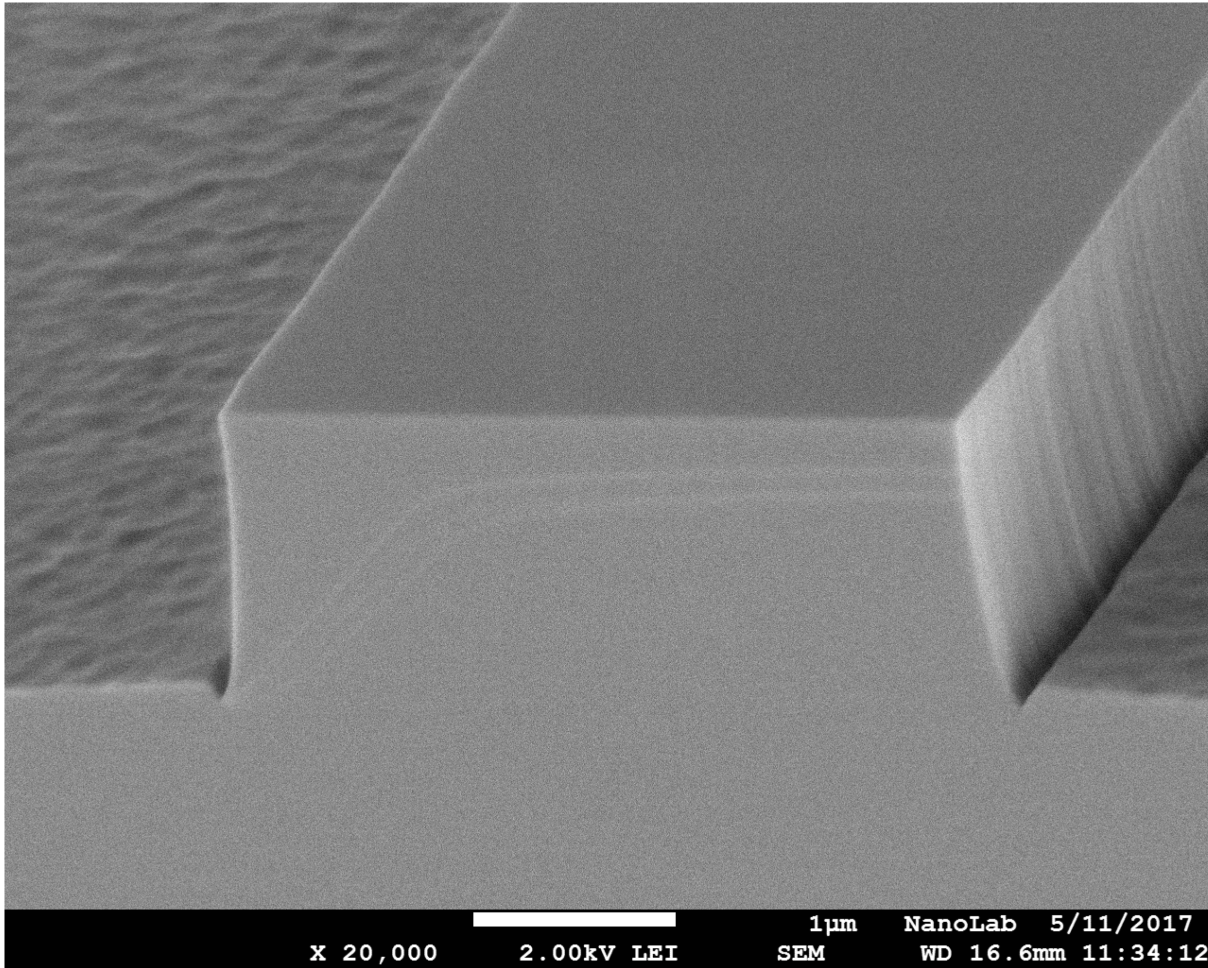
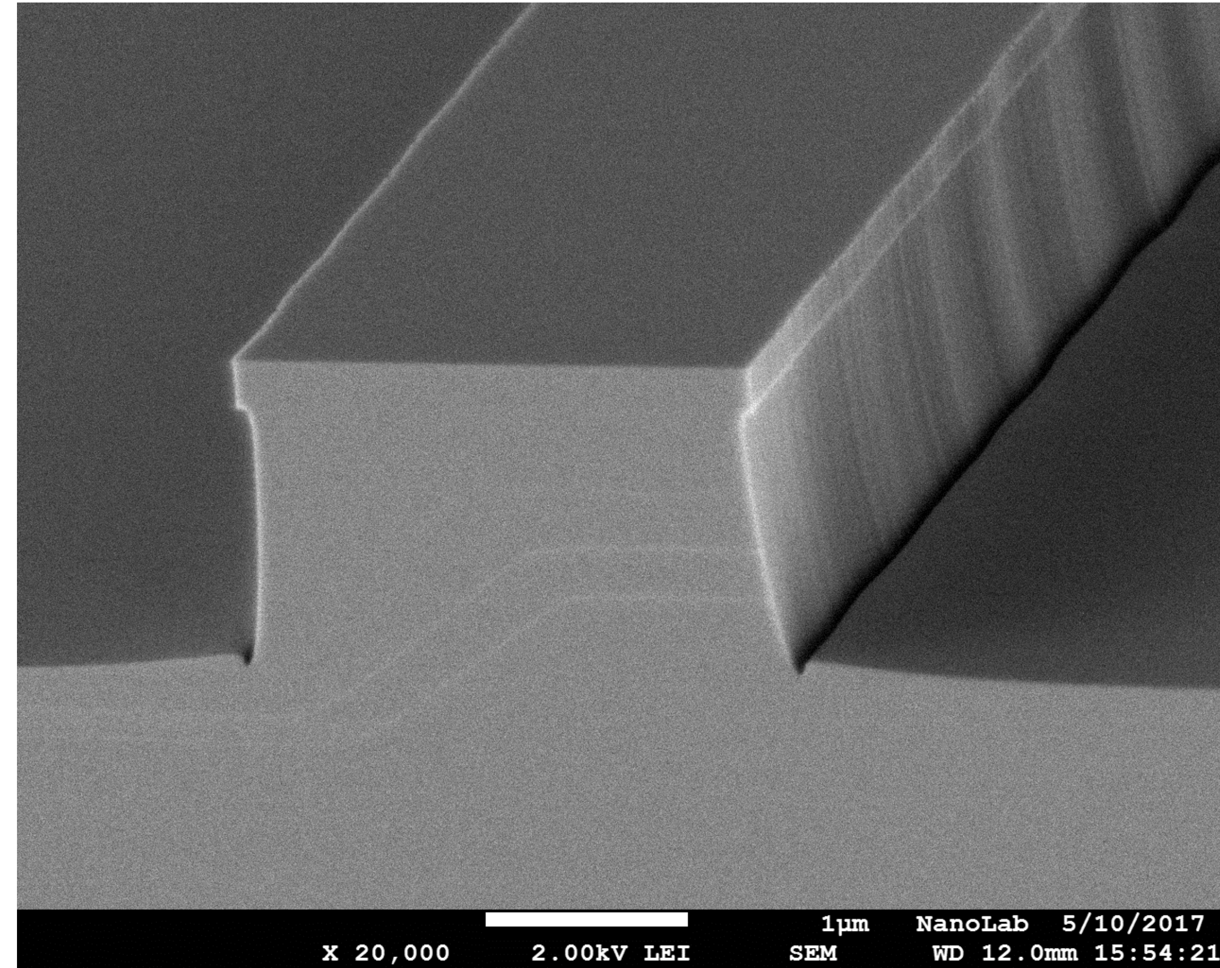


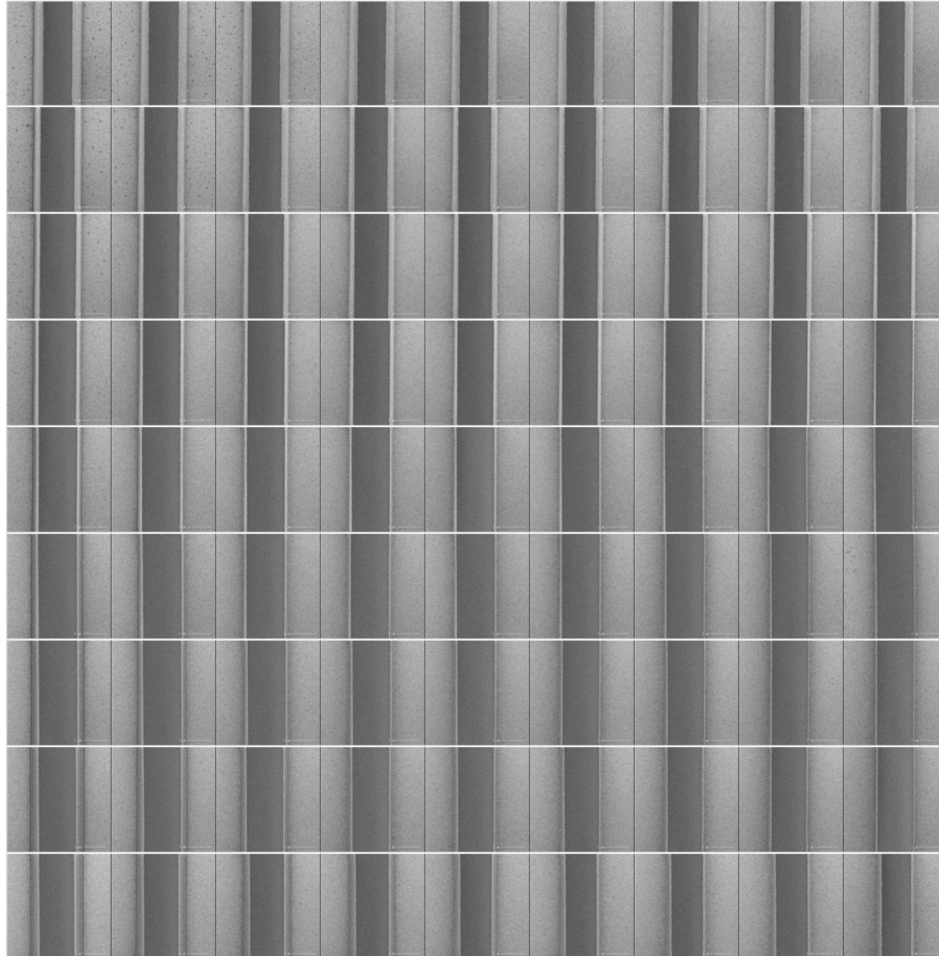
CH4-H2-Cl2 @60C

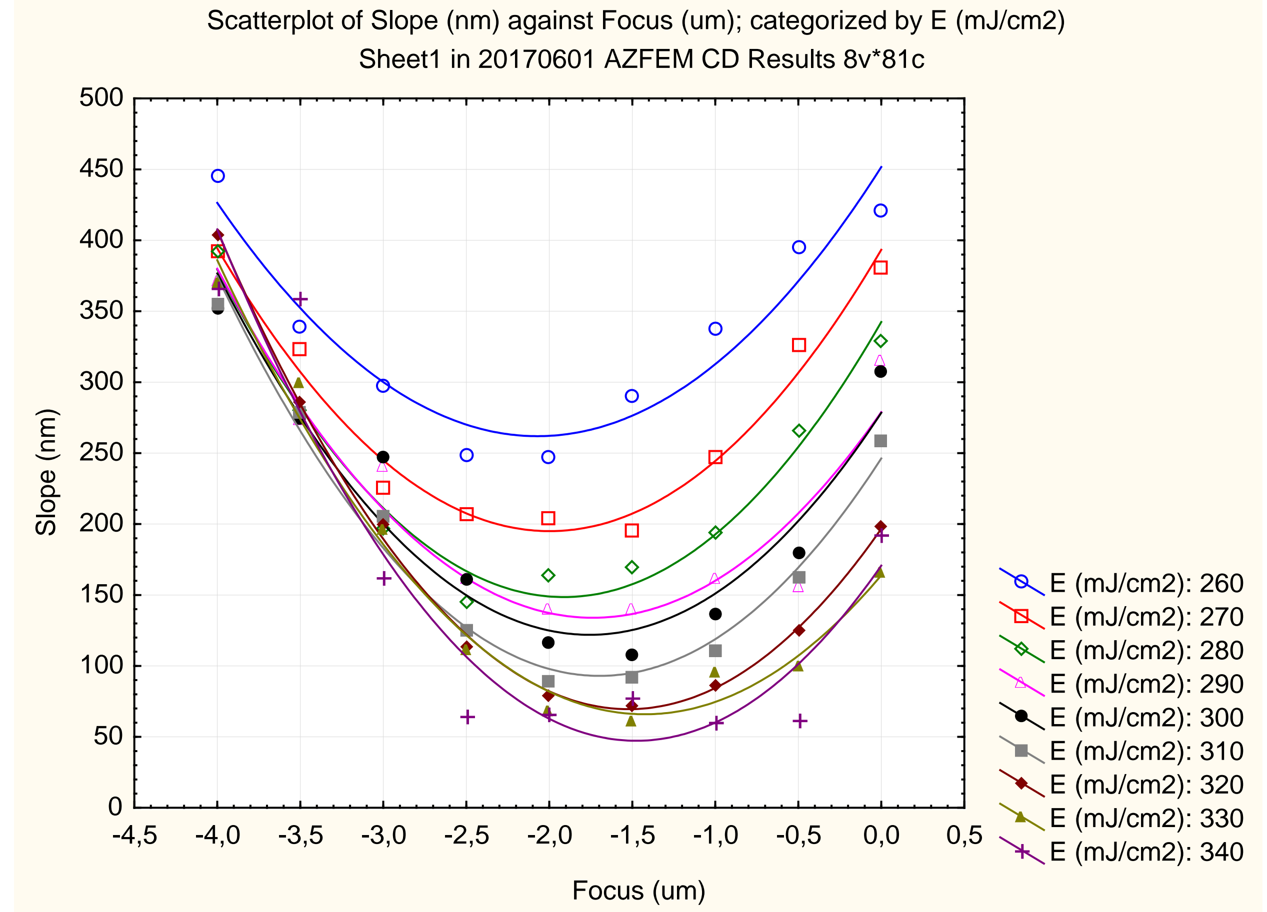


CH4-H2-Cl2 @200C

Task 5: Stepper lithography integration

- Equipment calibration and process development for AZ resist





Next period

- Al-MQW based modulators
  MQW ready (Dec 17) → etching, passivation (Jun 18) → joint MPW (Sep 18)
- Zn-diffusion integration
  Complete model of diffusion (Sep 17) → joint MPW (Dec 17) → transfer (Jun 18)
- Thick insulation and RF lines
  Material tests done (Oct 17) → joint MPW (Dec 17) → transfer (Jun 18)
- DUV lithography and etching
  CH4-H2 etch updated (Oct 17) → Cl2 etch ready (Mar 18)
- Stepper lithography integration
  MaN process ready (Sep 17) → Scanner-stepper test (Jan 18) → transfer (Sep 18)