TUSP

HIGH ENGERGY PULSE STACK HEC-DPSSL

Thilo Vethake, Head of Mechanical Design
Cranbury, 3/21/2014

At a glance

Company figures

	Fiscal Year 2012/13	Change in %
Sales (in mil. €)	2,343.4	+ 0.7
Income before taxes (in mil. €)	154.1	- 26.9
Investments (in mil. €)	136.1	- 10.8
Expenditure for research and development (in mil. €)	211.0	+ 9.1
Employees (as of 06/30/2013)	9,925	+ 3.9

Our business divisions

World market and technology leader in production technology

Machine tools	Laser technology	Electronics	Medical technology
			
Machine tools for flexible sheet metal and tube processing	Lasers for production technology	Power supplies for high technology processes	Equipment for operating rooms and intensive care units

Our business divisions

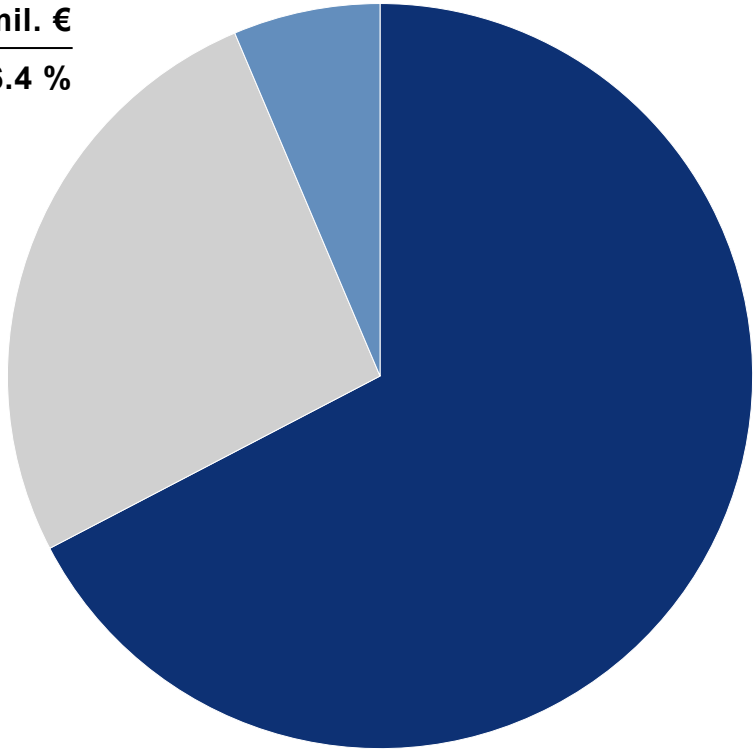
Share of sales

Medical technology

Sales 2012/13	**184 mil. €**
Share of sales	**6.4 %**

Laser technology / Electronics

Sales 2012/13	**758 mil. €**
Share of sales	**26.2 %**



Machine tools

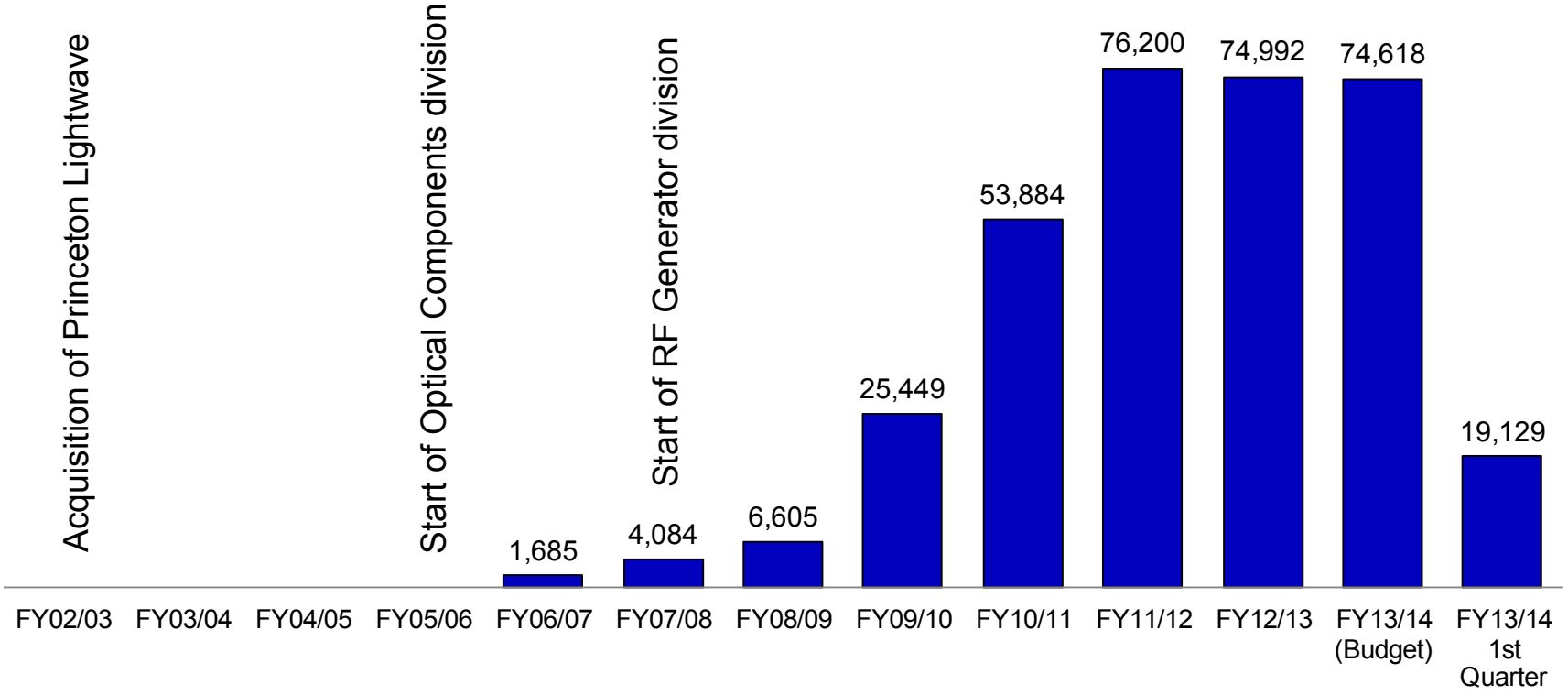
Sales 2012/13	**1,943 mil. €**
Share of sales	**67.4 %**

TRUMPF Photonics Inc., Cranbury, New Jersey

- Management: Dr. Treusch
- Employees: 143 (June 30th 2013)
- Sales: $ 75 Mio. (FY 12/13)
- Products: Laser Diodes / Laser Diode based Components, Optical Components, Solid State RF Generators

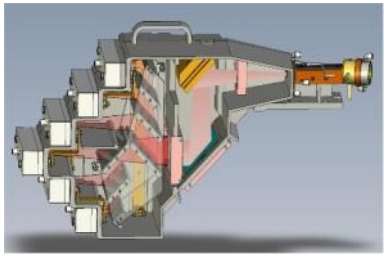
Development of Sales Revenue – TUSP total

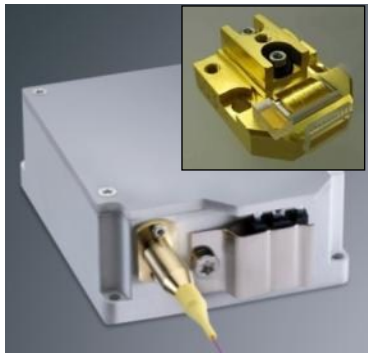
Sales in $k



Products and Business Fields TUSP

Diode Lasers		Optical Components	RF Generators
Pump Sources for TruDisk	TruDiode Module		



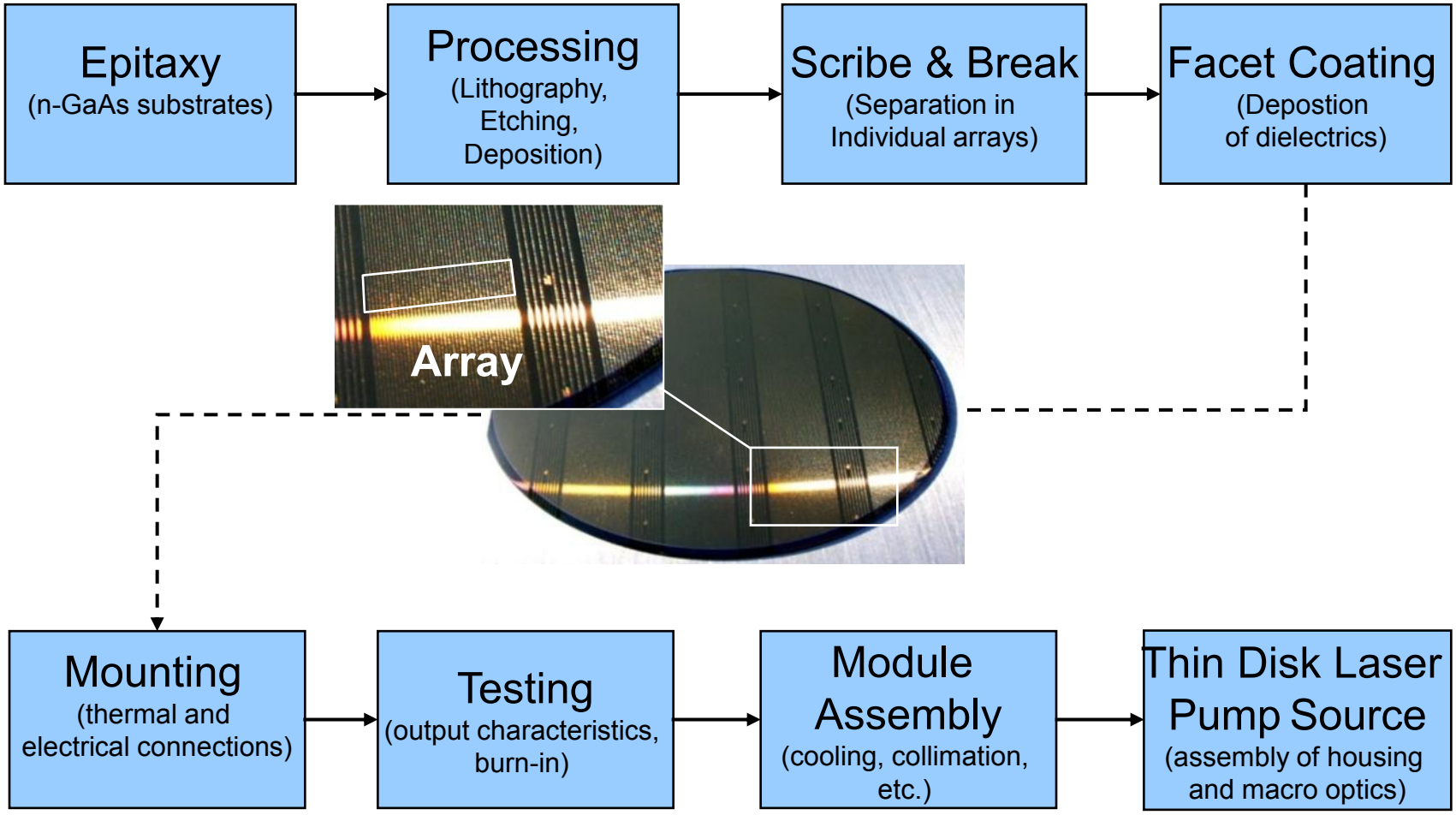


TruDisk / TruDiode lasers

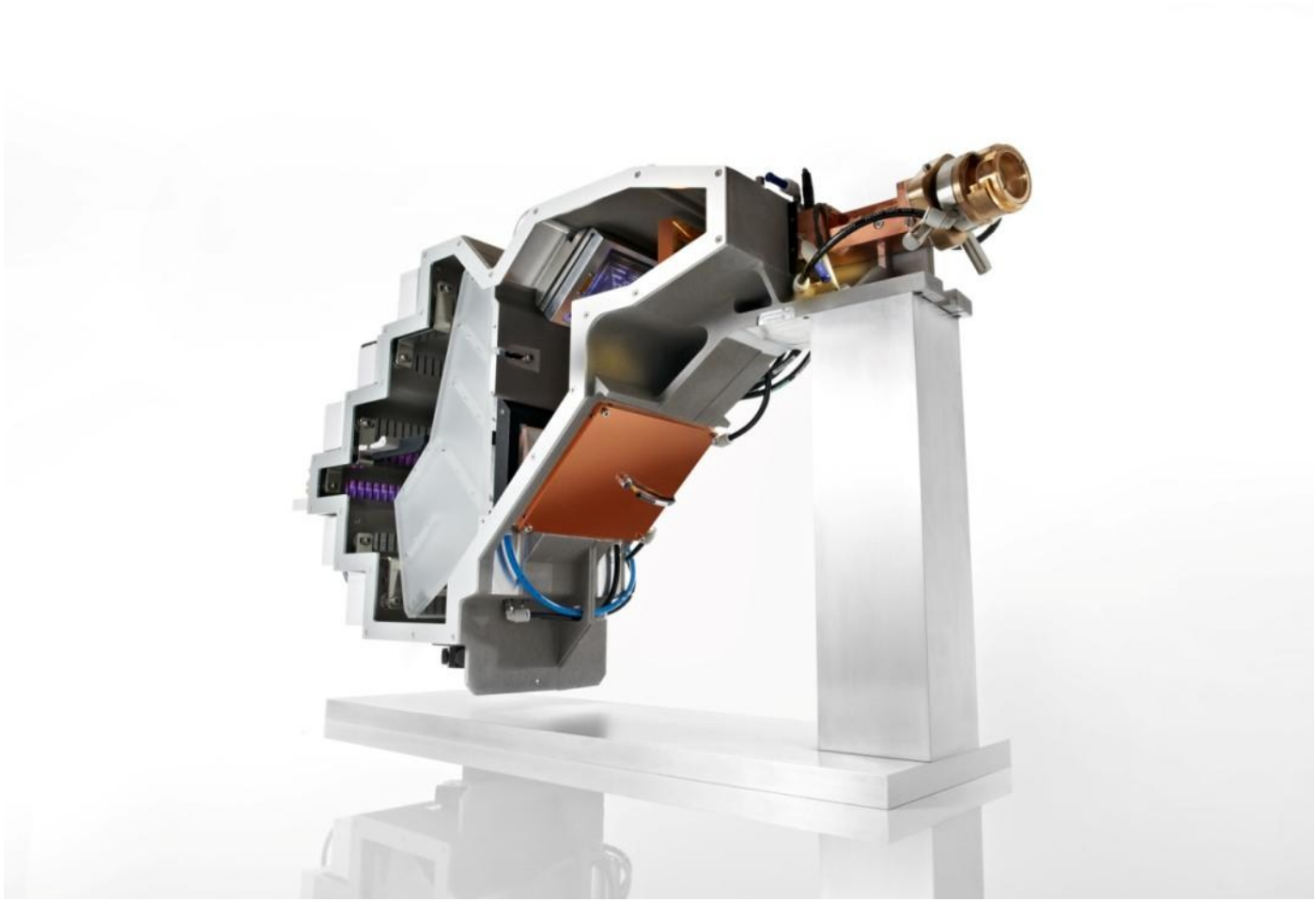
CO_2 lasers and beam guidance

CO_2 lasers

Laser diodes and Pump modules: Process flow



Module Assembly – 9-12 kW Pump Source

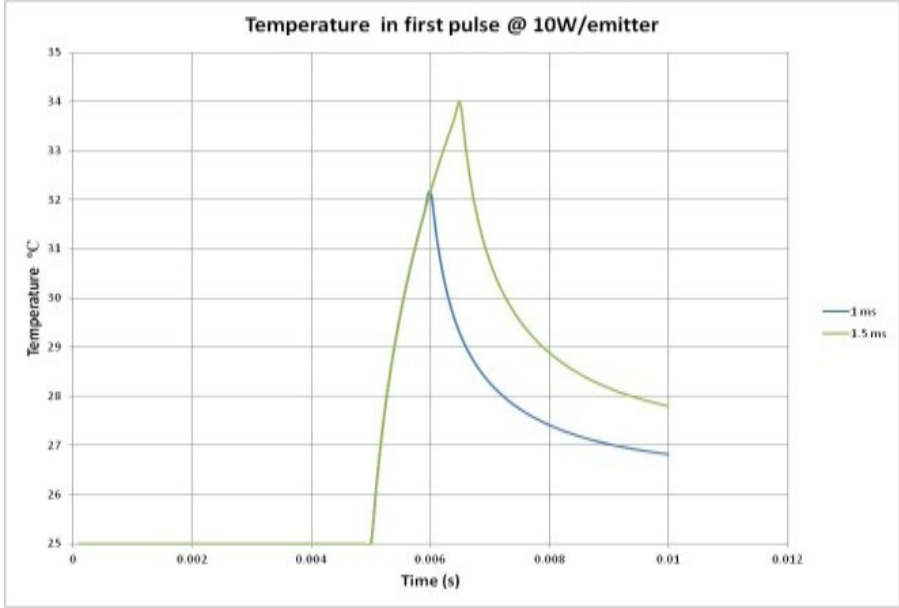


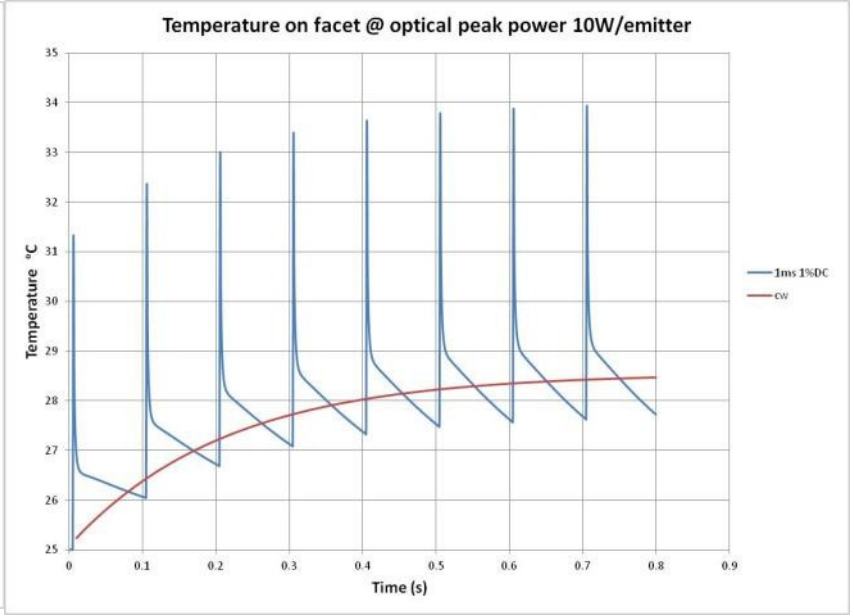
TUSP QCW pump

- Start of development in November 2012
- Goal: 400W/bar, later 500W/bar
- 25 bar stack 10kW, later 12.5 kW
- 26 1mm submounts, later 50 0.5mm submounts
- AuSn (hard solder) for the entire stack
- active water cooled, expansion matched cooler

Modeling of design

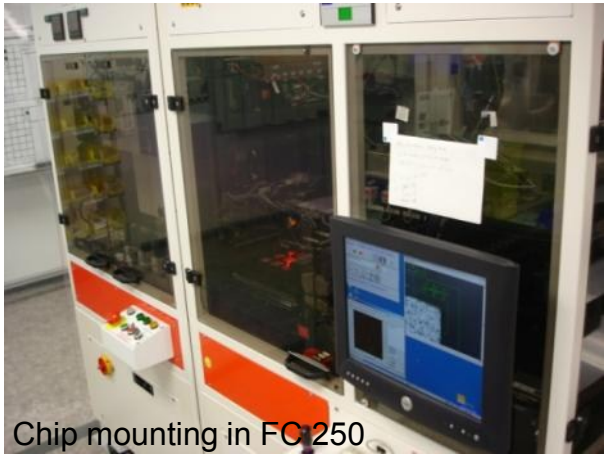
- thermal spike during single pulse
- thermal behavior during continuous pulsed operation (average and peak)





Trumpf laser bar results on standard cooler

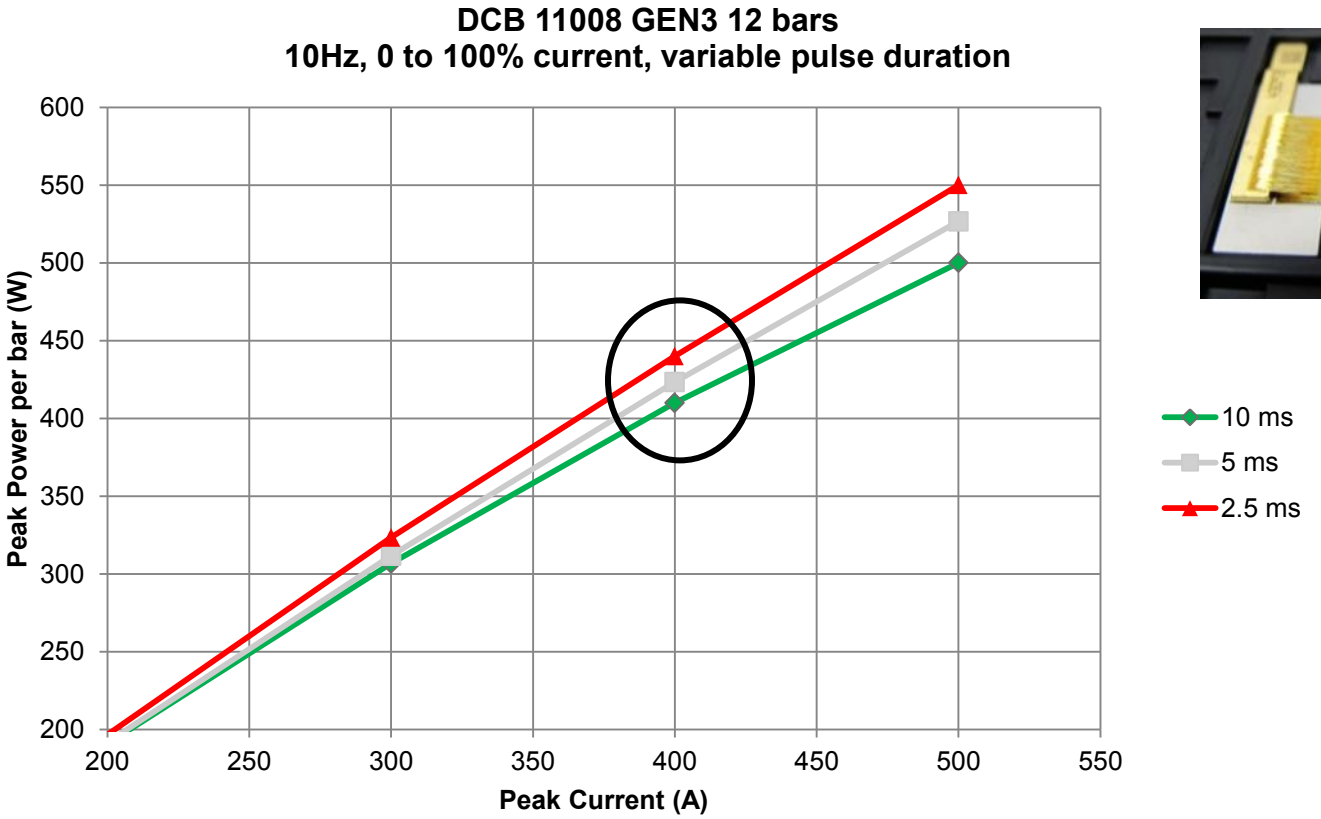
- Trumpf laser bar used in standard product (Pump source for disk laser)
- mounting process of 1st interface done on production equipment
- Laser on submount mounted on cooler
- This represents the chip performance under ideal cooling conditions



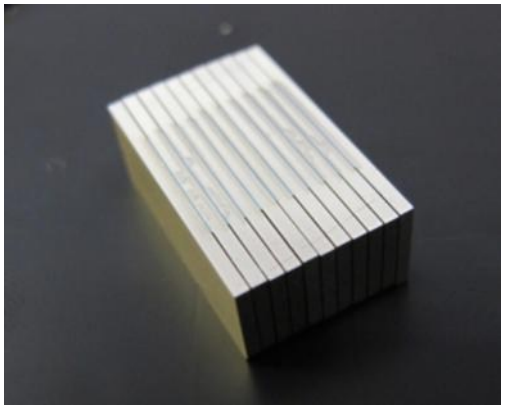
Chip mounting in FC 250

Trumpf laser bar results on standard cooler

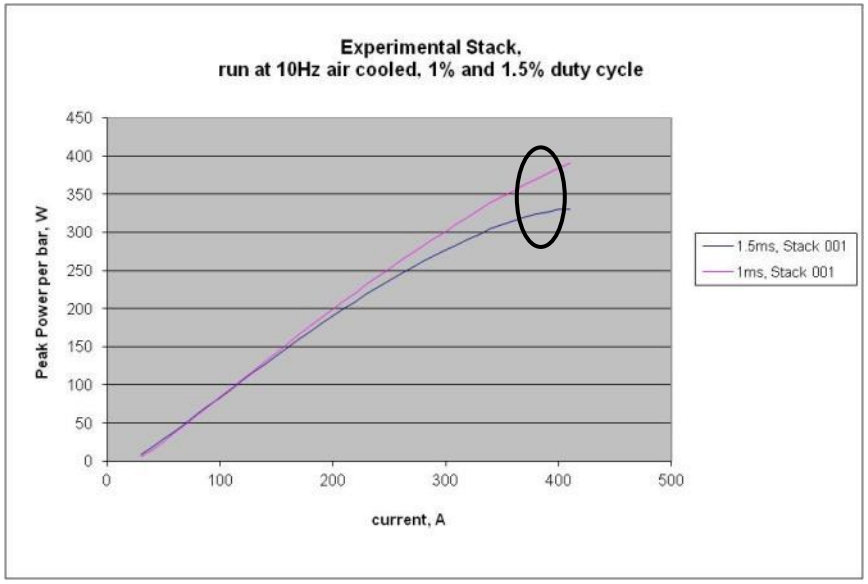
- the test results showed that with the appropriate cooling the diode material was able to perform at the operation point.

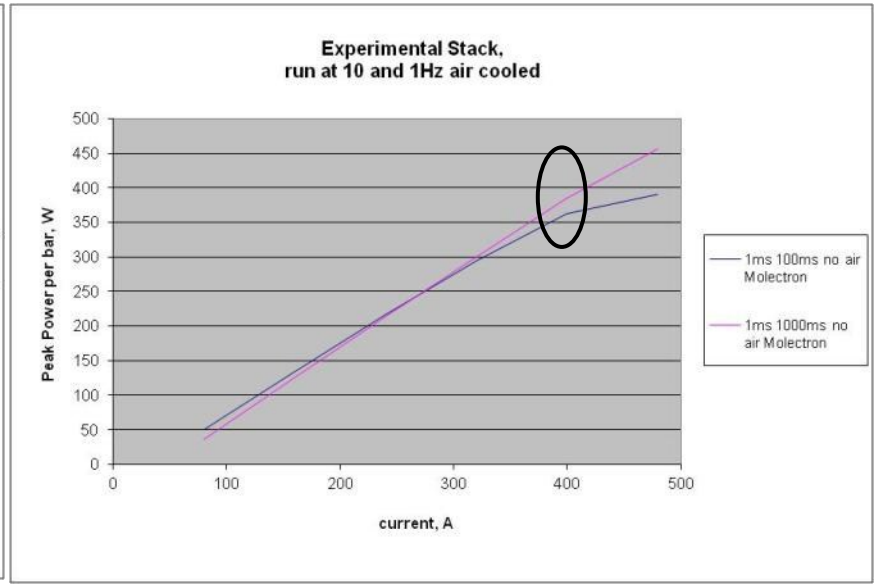


Experimental stack results



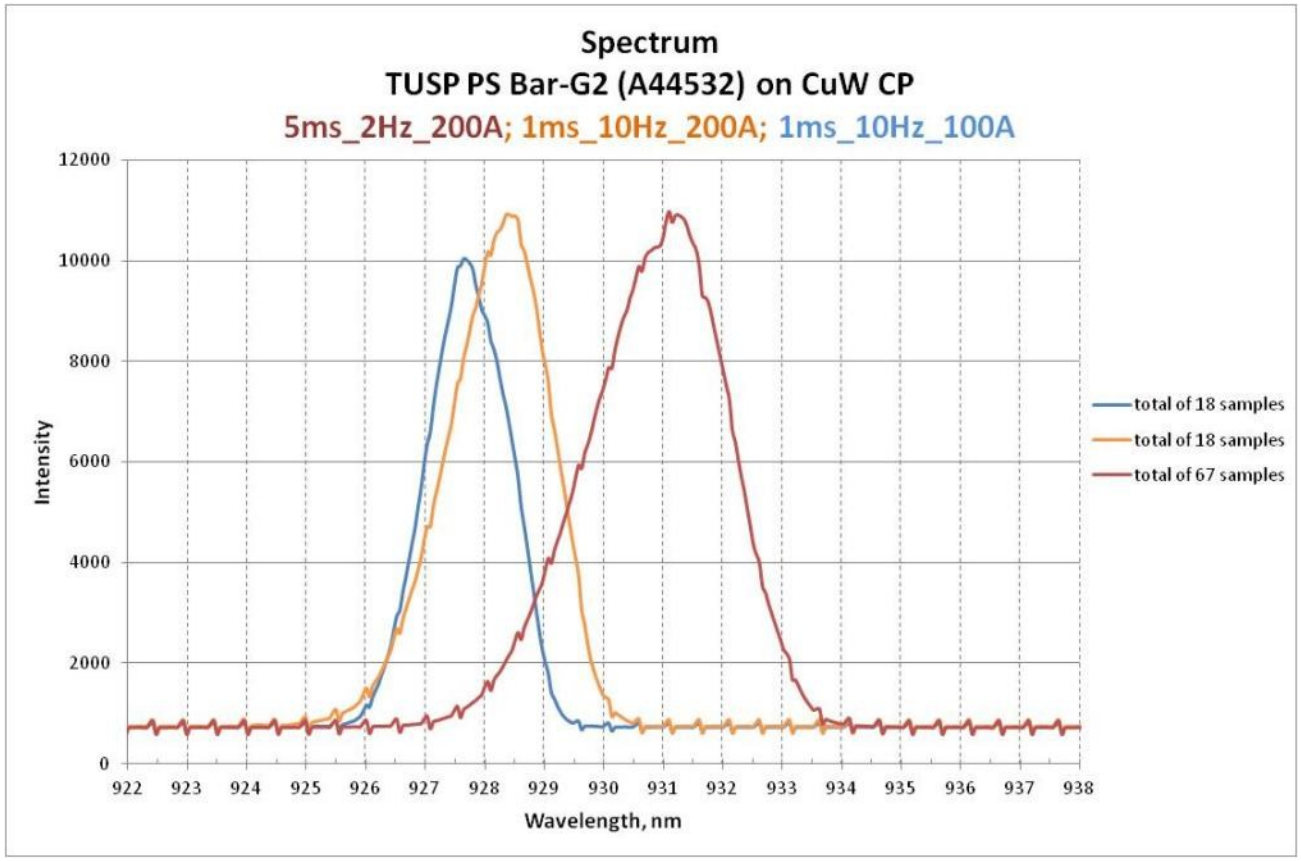
- The experimental stack showed the feasibility of the stacking technology
- Thermal rolling effects are to expect due to poor cooling or “air cooling”



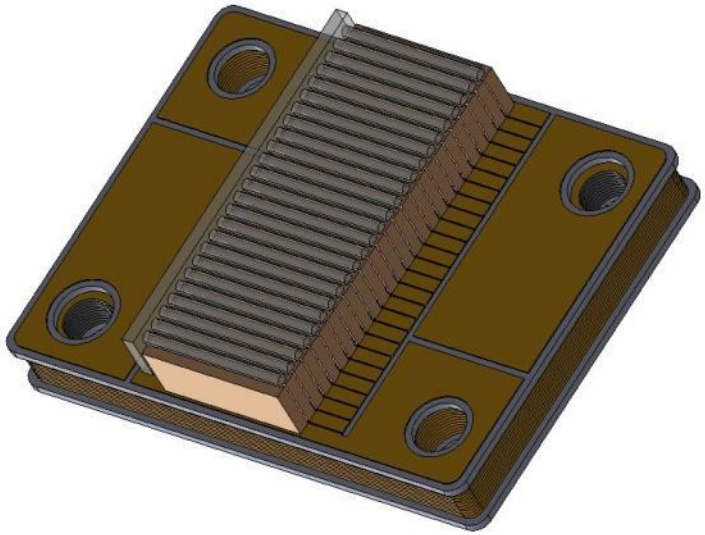


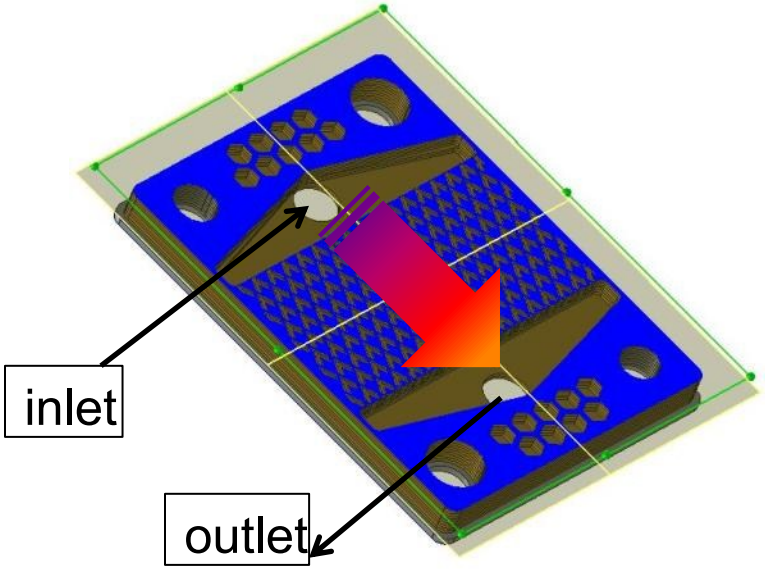
Trumpf laser bar results on standard cooler

- wavelength data is shown on a Pump source cooler
- widening of spectrum visible due to higher duty cycle
- ~4.5 nm spectral width for 67 samples, shows repeatability



Introduction of stack design

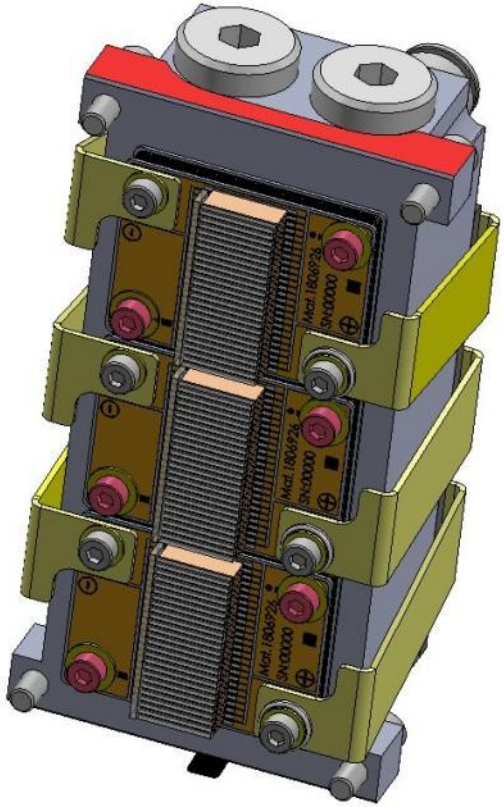




- Stack consists of 25 laser bars @ 500W peak power each
- Stacked on an insulated cooler

- Seals to manifold via O-Rings
- Quasi porous structure allows for insensitivity against clogging and efficient cooling

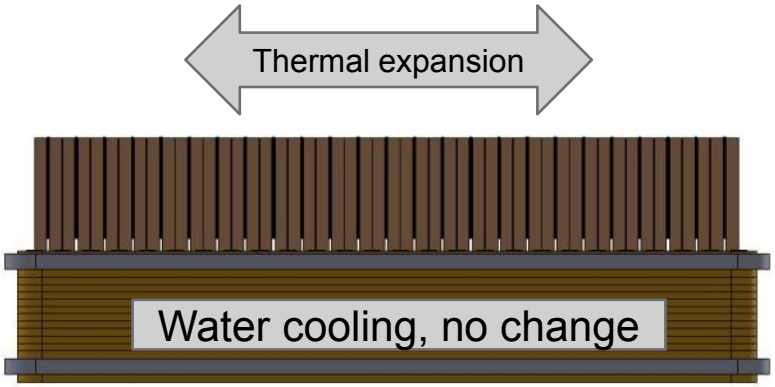
Introduction of stack design

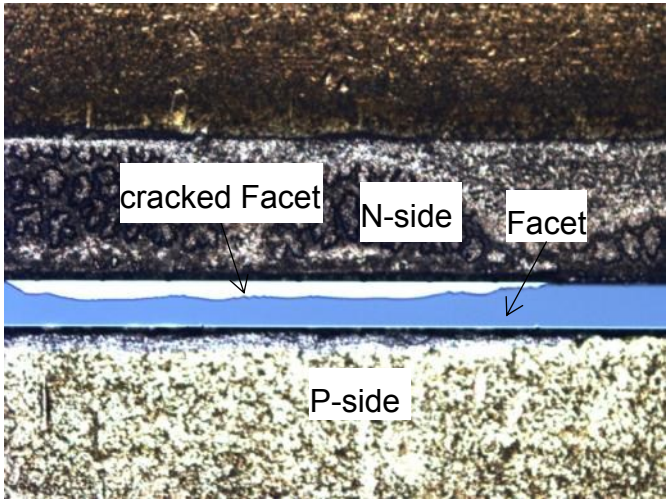


- Manifold becomes mounting base for accurate reference in lensing
- Manifold distributes cooling water to 3 stacks
- Modular concept allows upgrading and downgrading to different power configurations

TUSP QCW pump

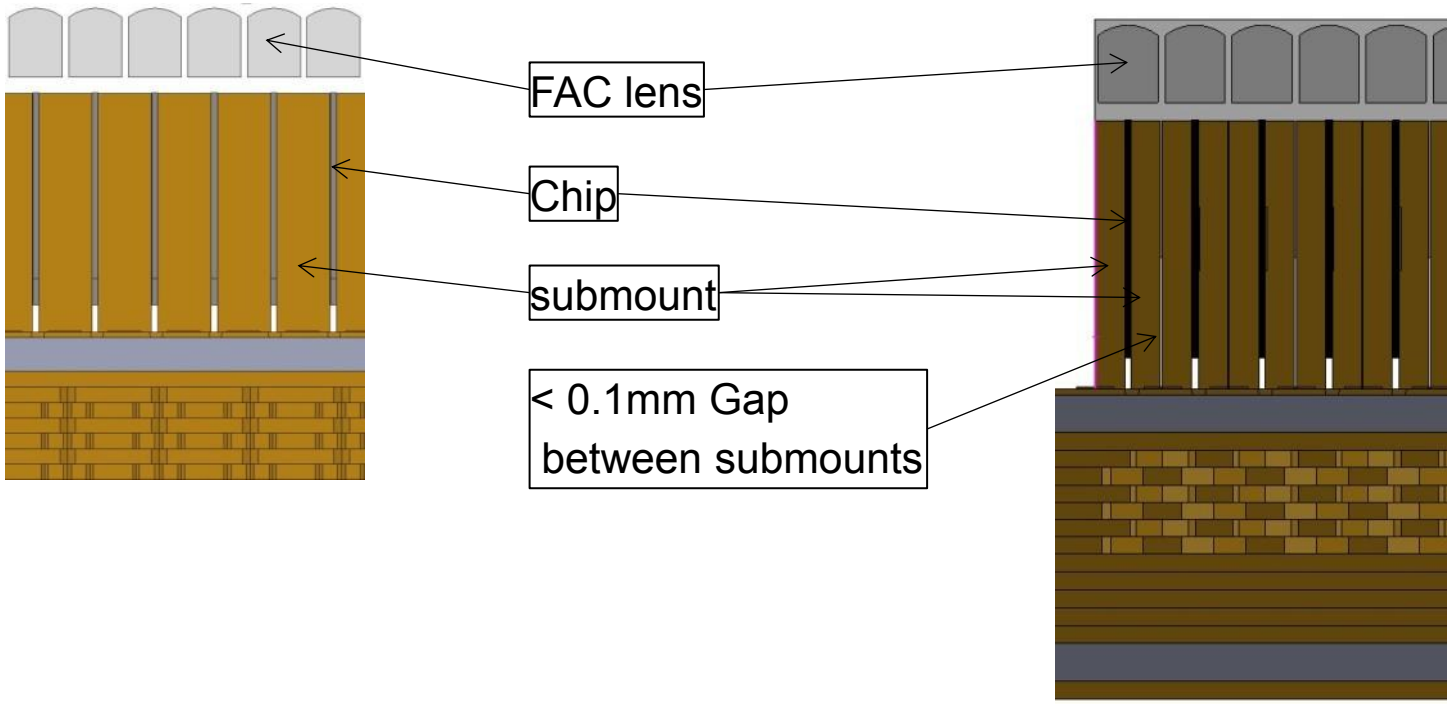
- Expansion matching of cooler to stack:
- The first builds resulted in horizontal cracks
- Some of the cracks only showed up after testing up to 500A
- Due to warmer front and colder back





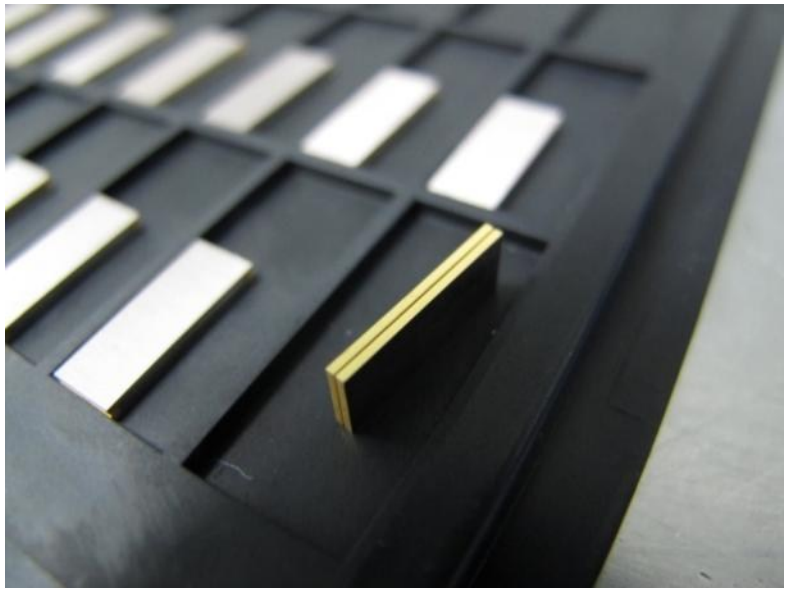
TUSP QCW pump

- The solution was to go to a sandwich configuration
- The sandwiches allow for individual movements
- Gap allows for individual thermal expansion



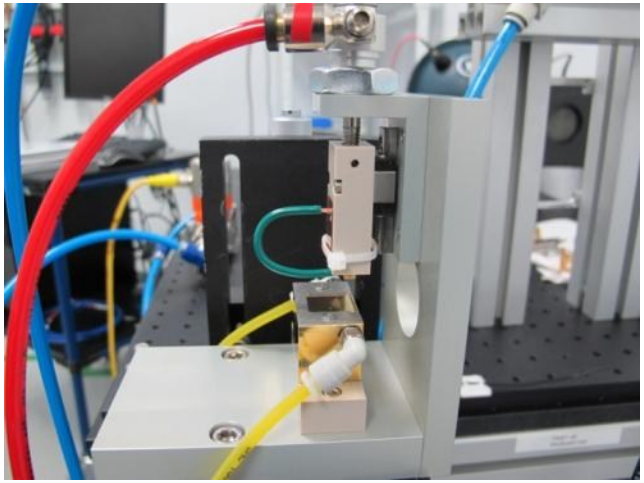
TUSP QCW pump

- Sandwich build
  - 1st interface (AuSn) mounting is done on a automated bonding tool (Suess FC250)
  - sub µm placement accuracy of chip on cooler
  - 2nd submount is also mounted on automated bonding tool with AuSn solder



TUSP QCW pump

- The Sandwich test allows testing of the parts that will be used in the later stack
- Characterization of power and wavelength are done, near field and smile measurements are possible.
- This step allows us to reduce scrap and increase the yield for the stack build



				Amtron	Amtron				
				500 A	500 A				
				1 ms	1 ms				
				1 % DC	1 % DC				
				0.4 GPM (1.5 LPM)	0.4 GPM (1.5 LPM)				
				25 degree C	25 degree C	Dilas	Dilas	Dilas	Dilas 100A
Fusion	Count	Serial No	Voltage [mV]	Power [W]	Centroid WL [nm]	No Emitters C	Centroid W	90% Band	Centroid WL [nm]
	1	1_01_01		4.91	948.5				938.3
	2	1_01_02		4.80	948.5				
	3	1_01_03		4.57	949.6				
	4	1_01_04		3.22	953.6				
	5	1_01_05		4.41	950.7				
	6	1_01_06		4.84	948.8				
	7	1_01_07		3.48	953.6	**misaligned**			
	8	1_01_08		0.70	dual	**failed**			
	9	1_02_01		4.80	949.5				
	10	1_02_02		4.78	949.9				
	11	1_02_03		4.87	948.4				
	12	1_02_04		4.54	949.3				
	13	1_02_05		3.51	950.4				
	14	1_02_06		4.91	948.1				
	15	1_02_07		0.40	961.1				
	16	1_02_08		4.41	951.7				
	17	1_03_01		4.88	949.1				
	18	1_03_02		4.87	949.2				
	19	1_03_03		4.76	949.7				
	20	1_03_04		4.24	953.4				
	21	1_03_05		4.00	952.6				
	22	1_03_06		4.50	951.1				
	23	1_03_07		4.93	948.8				
	24	1_03_08		4.59	950.4				
	25	2_01_01		4.80	948.9				938.9
	26	2_01_02		4.80	948.9				
	27	2_01_03		2.41	953.8				
	28	2_01_04		2.97	954.4				
	29	2_02_01		4.59	949.2				
	30	2_02_02		3.15	951.8				
	31	2_02_03		4.85	949.3				
	32	2_02_04		4.75	948.9	**misaligned**			
	33	2_03_01		4.87	949.2				
	34	2_03_02		2.71	953.4				
	35	2_03_03		3.47	951.90				
	36	2_03_04		4.49	950.5				

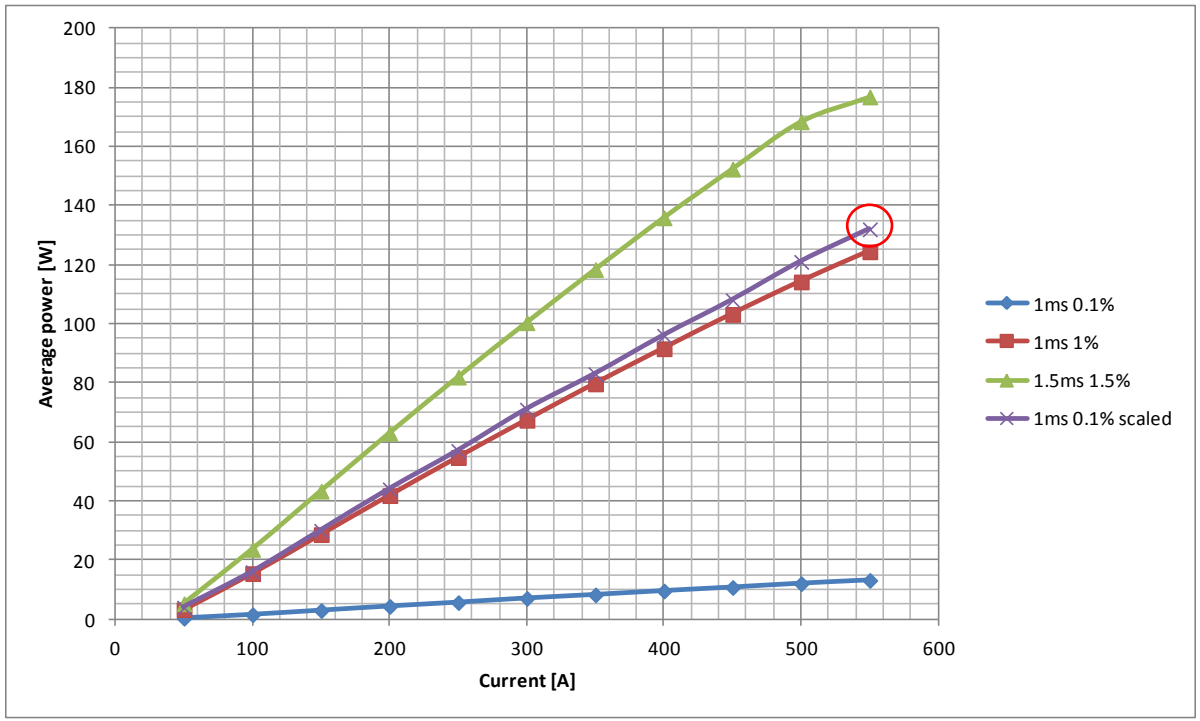
no data taken with sphere

No data recorded

No data recorded

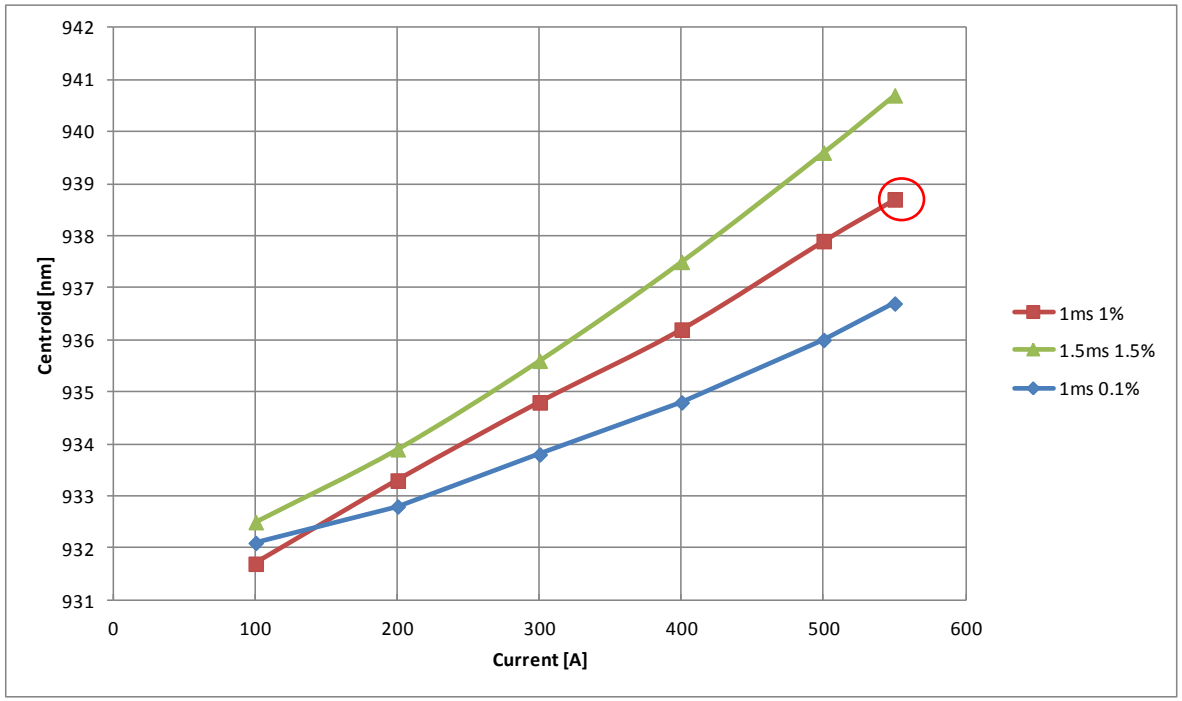
TUSP QCW pump

- Power reached was 114W working on qualification 125W
- The purple line shows a scaled curve where 4% of the power are added to compensate for a shorted bar
- The green curve is measured at 1.5% duty cycle and shows some thermal rolling.



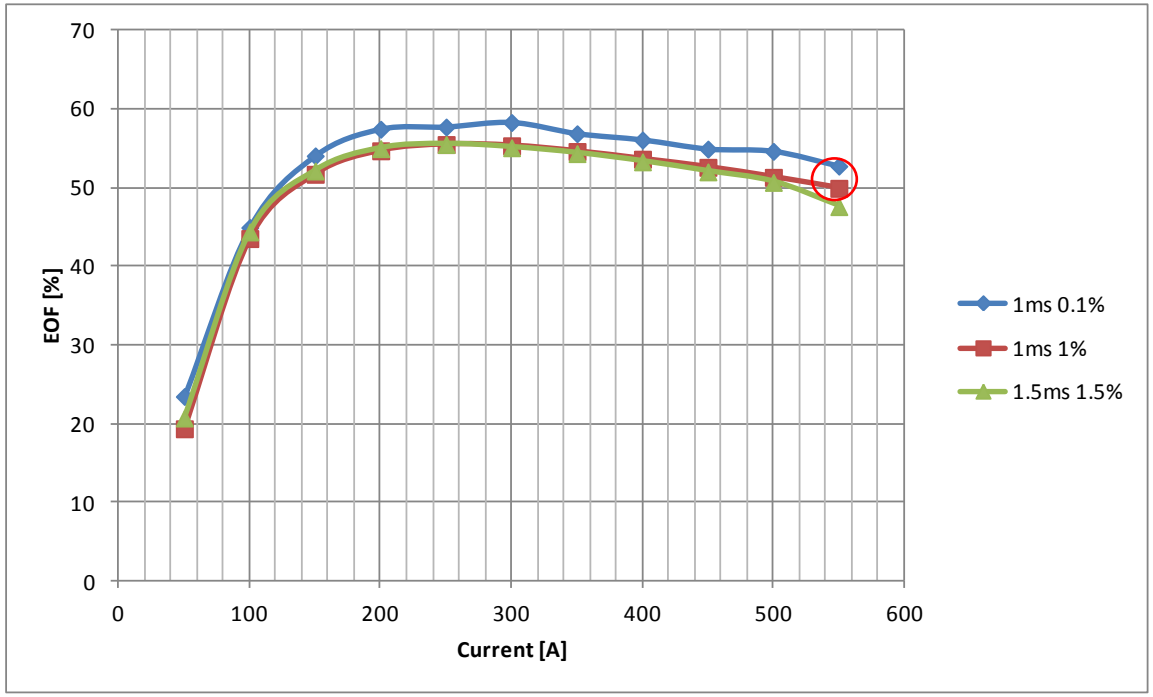
TUSP QCW pump

- The wavelength for 1% duty cycle at 550A is 938.8nm, 939.5nm were the goal. The difference can be adjusted with a bias current.
- For lower duty cycles the wavelength is shorter due to less heating, for higher duty cycles the wavelength increases
- 0.1% duty cycle shows mainly the heating of the individual pulse

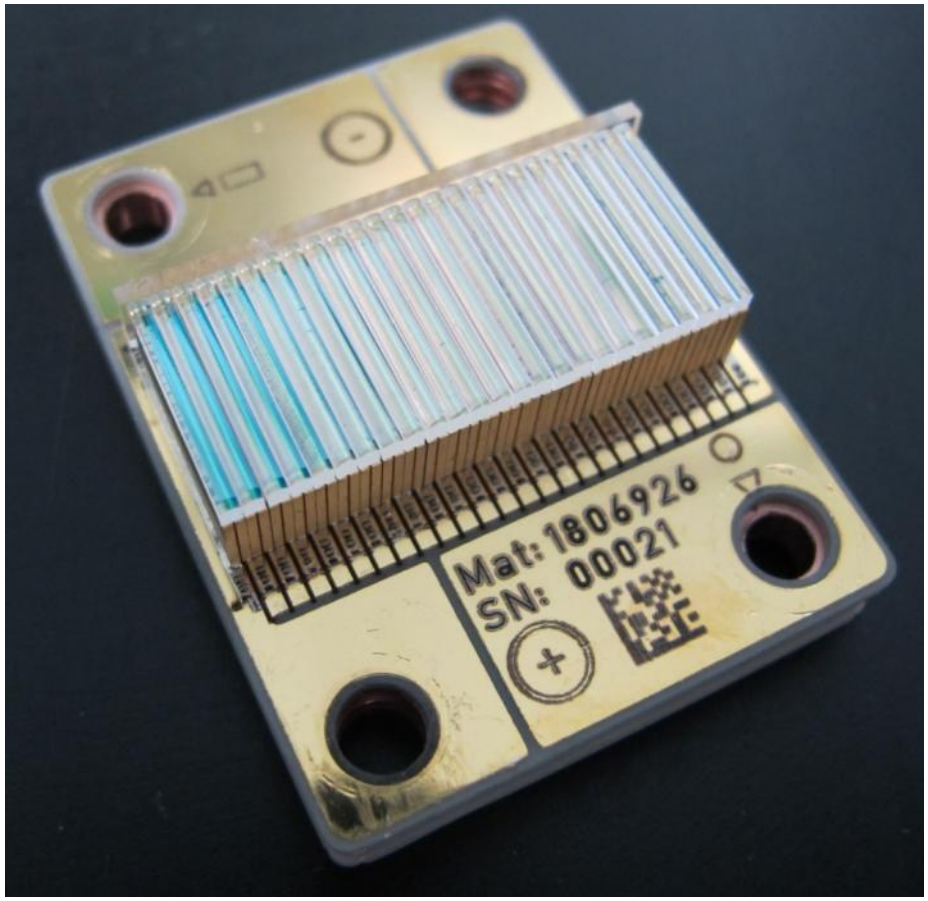


TUSP QCW pump

- Top electro-optical efficiency can be achieved at 300A with 58% for 0.1% duty cycle
- At the operation point at 550A and 1% duty cycle the EO efficiency is 50%



TUSP QCW pump



Thank you for your attention !

I am looking forward to your questions..