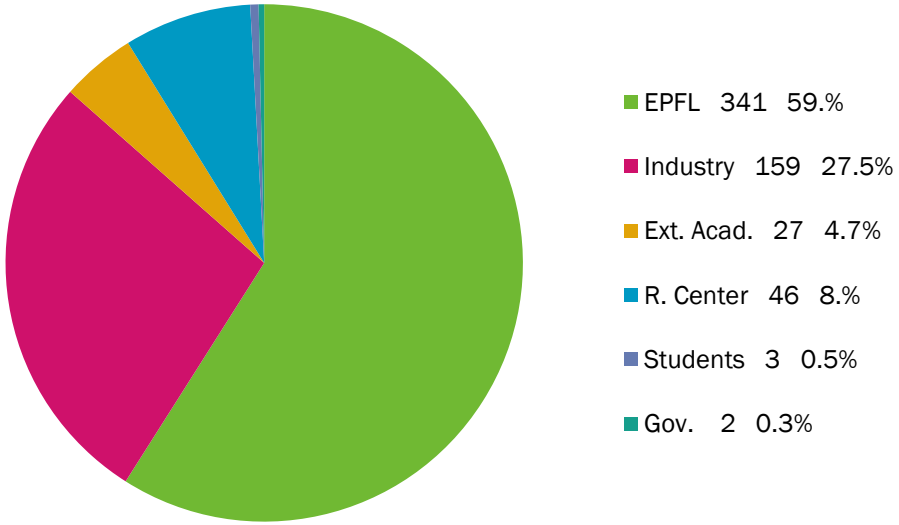
Next editions :

- 19th 08.05.2018
- 20th 07.05.2019

EPFL MICRONANOFABRICATION ANNUAL REVIEW MEETING

WELCOME & THANKS

- Welcome to the 18th edition of the CMi MicroNanoFabrication Annual Review Meeting
- 578 participants registered (with 28% from industry)
- Many thanks for your participation



- Global companies
- Local industry
- Startups
- Suppliers
- Government Agencies
- Researchers
- Faculty members
- Colleagues from other cleanrooms

- -> Traveling from 10 different countries
- -> Networking

OUTLINE

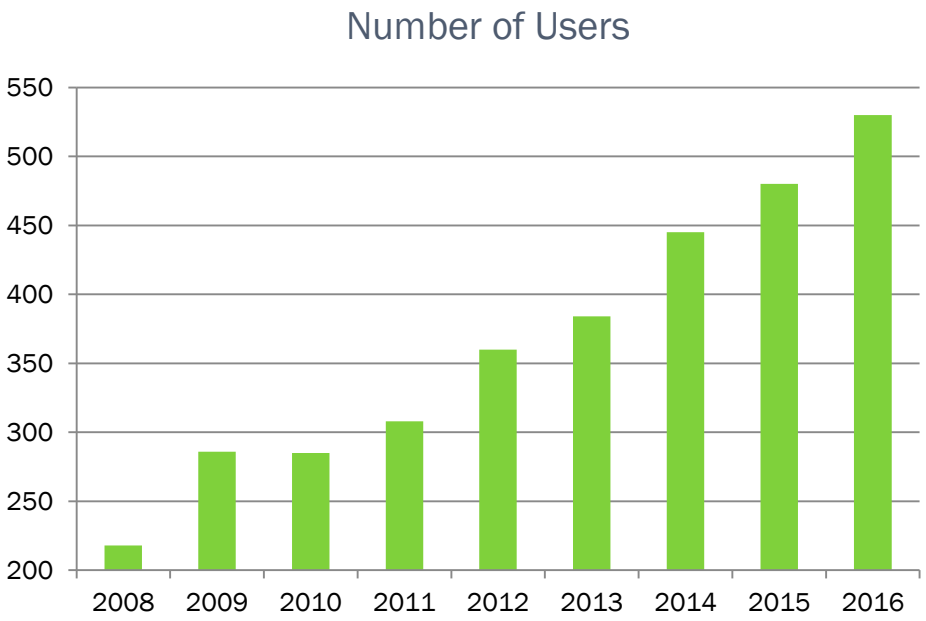
- Users
- Fees
- Staff
- Cleanroom
- Tools
- Projects

USERS IN 2016

EPFL Engineering Sc.		Basic Sc.	Life Sc.	Ext. Ac.	Companies	
CMi	STI-IMT-LMIS2	SB-CMNT-GE	SV-GHI-UPKIN	EXT-CERN	EXT-Aleva	EXT-SilMach
STI-IBI-BIOS	STI-IMT-LMIS4	SB-IPHYS-GCMP	SV-IBI-LDCS	EXT-CSEM-T1	EXT-Asulab	EXT-SwissTo12
STI-IBI-CLSE	STI-IMT-LMTS	SB-IPHYS-LASPE	SV-IBI-LLCB	EXT-CSEM-T3	EXT-Bruker	EXT-Synova
STI-IBI-LBEN	STI-IMT-LO	SB-IPHYS-LOEQ	SV-IBI-LMRP	EXT-CSEM-Mut.	EXT-Colibrys	EXT-TESCAN
STI-IBI-LBNC	STI-IMT-LOB	SB-IPHYS-LPMC	SV-IBI-UPDEPLA	EXT-EMPA	EXT-Efficonseil	EXT-Tronics
STI-IBI-LBNI	STI-IMT-LPMAT	SB-IPHYS-LPMV	SV-IBI-UPLUT	EXT-ETHZ	EXT-EXALOS	EXT-ValFleurier
STI-IBI-LHTC	STI-IMT-LSBI	SB-IPHYS-LPN	SV-IBI-UPNAE	EXT-HEIG-VD	EXT-Hamamatsu	
STI-IBI-LNE	STI-IMT-NAM	SB-IPHYS-LPQM1	SV-ISREC-CDTSO	EXT-HESGE	EXT-Hightec	
STI-IEL-GR-SCI	STI-IMT-NE-PV-LAB	SB-IPHYS-LUMES	SV-PTBIOEM	EXT-HESNE	EXT-Intel	
STI-IEL-LANES	STI-IMT-OPT	SB-ISIC-LCPM		EXT-Bucharest	EXT-Karmic	
STI-IEL-LEMA	STI-IMT-PV-LAB	SB-ISIC-LEPA		EXT-Inst-Pasteur	EXT-LémanMicro	
STI-IEL-LSI2	STI-IMX-FIMAP	SB-ISIC-LND	IC-IINFCOM-LSI1	EXT-Belo-Horiz.	EXT-LESS_SA	
STI-IEL-LSM	STI-IMX-LC	SB-ISIC-LPI		EXT-UNIBE-Phys.	EXT-LSPR	
STI-IEL-NANOLAB	STI-IMX-LMGN	SB-ISIC-LSCI	ENAC-IIC-LESO-PB	EXT-UniFribourg	EXT-Lunaphore	
STI-IEL-PHOSL	STI-IMX-LMM	SB-ISIC-LSPM		EXT-UNIGE-GAP	EXT-Mackinac	
STI-IEL-POWERLAB	STI-IMX-LMOM	SB-ISIC-LSU		EXT-UNIGE-Sugi.	EXT-Meister-Abrasive	
STI-IGM-LRESE	STI-IMX-LMSC	SB-SPC-PP		EXT-UNIL	EXT-Morphotonix	
STI-IGM-MICROBS	STI-IMX-LP			EXT-Wyss_Cent	EXT-Nanoworld	
STI-IMT-ESPLAB	STI-IMX-LTP				EXT-Novagan	
STI-IMT-GR-LVT	STI-IMX-SMAL				EXT-Piemacs	
STI-IMT-GR-QUA	STI-IMX-SUNMIL				EXT-Qwane	
STI-IMT-LAI	STI-SCI-CD				EXT-Rolex	
STI-IMT-LAPD	STI-SCI-PM				EXT-Samtec	
STI-IMT-LMIS1					EXT-Sigatec	
342 (47)		65 (17)	37 (11)	40 (18)	46 (30)	

- Total: 530 users (+10%) operating the CMi tools
- Total: 123 labs or companies (+23%)

USERS IN 2016



Nanofabrication plays an increasing role in modern science.

- The number of Users is steadily increasing at an average rate of 12% per year since 2008
- Our prevision is to maintain the growth rate at around 10% per year for the next 5 years (new labs)

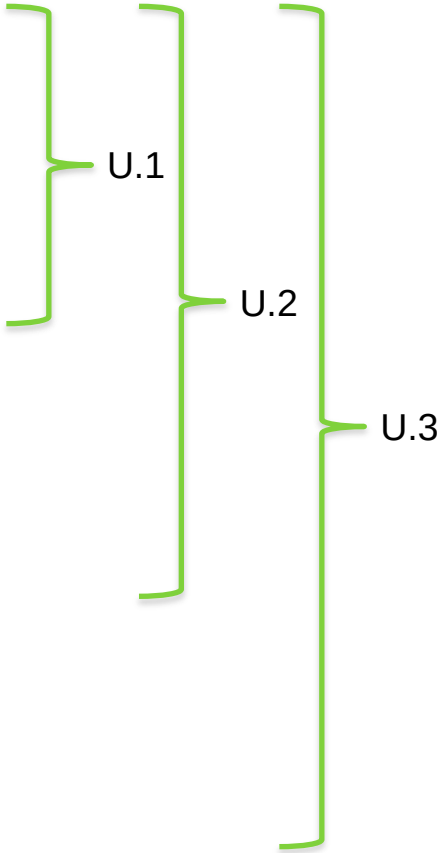
FEES

- NEW fees system in place since October 1st 2016

- EPFL has converged with the SNSF on a transparent cost accounting methodology for our major common research facilities
  - Center of MicroNanoTechnology (CMi)
  - Centre for Electron Microscopy (CIME)
  - High Performance Computing (SCITAS)
  - Animal Housing (CPG)
- The good news for the users: the direct infrastructure costs are eligible from funding bodies
- The constraint: the cost accounting must be homogenous across facilities, transparent, and auditable by the funding agencies to ensure that utilization costs are eligible
- The Methodology: a unified cost structure has been designed with separate cost categories:
  - Direct costs
  - Other direct costs (i.e. maintenance and depreciation)
  - Indirect costs (overheads)

FEES

- Direct costs
  - Salaries and social charges of operational personnel
  - Consumables
  - Fluid costs
  - Energy (for equipment where this variable cost is significant)
  - Goods of non-enduring value (≤ 4 years)
  - Others
- Other direct costs
  - Salaries and social charges of maintenance personnel
  - Maintenance costs
  - Depreciation (for equipment with duration ≥ 5 years)
  - Others
- Indirect costs
  - Salaries and social charges of administrative personnel
  - Salaries and social charges of central services personnel
  - Rent and running expenses of the facility
  - Others



- Internal EPFL Users : U1
- External Academic Users : U2
- Industrial Users : U3

FEES

		TOTAL	Laser Writer	Coater Developer Auto	Coater Developer Manu	Mask Aligner	Hot Plate	E-Beam Writer	Dry Etcher	LPCVD, ALD	Thermal Process	PVD Auto	PVD Manu	SEM, FIB	AFM	Other measur. tools	Wet bench	PDMS Line	Packaging	Other tools
Yearly operational costs, CHF																				
Direct costs																				
1.1 Salaries and social charges of operational personnel		***1'374'001***	81'493	119'216	57'289	83'631	42'616	113'677	130'611	68'092	31'792	123'467	10'853	96'622	27'883	80'744	160'625	22'292	75'785	47'314
1.2 Consumables		***495'046***	8'544	162'031	6'752	10'949	10'261	30'145	31'972	40'745	6'225	56'102	1'605	13'016	2'454	7'366	47'478	11'453	35'663	12'286
1.3 Fluid costs		***164'348***	-	4'626	3'605	2'796	-	4'690	26'378	7'328	5'277	17'704	890	7'780	-	-	83'274	-	-	-
1.4 Energy (for equipment where this variable cost is significant)		***302'496***	9'940	19'170	14'938	11'588	25'418	19'435	48'194	13'389	9'641	32'345	3'687	32'243	-	-	48'101	-	14'407	-
1.5 Goods of non-enduring value (≤ 4 years)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.6 Others		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total direct costs	CHF	***2'335'891***	99'977	305'042	82'584	108'964	78'295	167'946	237'155	129'554	52'934	229'618	17'035	149'661	30'338	88'109	339'478	33'745	125'855	59'600
Other direct costs																				
2.1 Salaries and social charges of maintenance personnel		***357'706***	31'049	19'823	5'486	7'802	3'222	48'207	42'387	18'646	19'279	42'612	2'373	27'634	4'155	9'660	44'527	7'008	16'623	7'213
2.2 Miantenance contracts		***691'325***	68'337	38'468	9'015	19'620	4'074	81'294	99'959	44'078	33'877	93'863	3'938	66'351	8'613	17'692	59'200	5'950	27'605	9'390
2.3 Depreciation (for equipment with duratoin ≥ 5 years)		***1'144'946***	94'783	157'214	12'404	17'550	1'205	182'074	171'739	131'308	36'482	104'333	8'045	75'276	34'344	47'553	8'636	2'600	47'164	12'236
2.4 Others		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total other direct costs	CHF	***2'193'977***	194'169	215'506	26'905	44'971	8'501	311'576	314'085	194'033	89'638	240'808	14'356	169'261	47'112	74'905	112'363	15'558	91'391	28'839
Indirect costs																				
3.1 Salaries and social charges of administrative personnel		***860'101***	46'811	47'060	27'530	28'299	42'374	61'470	124'992	42'352	28'599	94'723	7'423	83'671	11'757	27'572	94'476	22'242	33'426	35'327
3.2 Salaries and social charges of central services personnel		***172'170***	4'836	9'327	7'268	5'638	12'367	9'456	23'449	6'514	4'691	15'737	1'794	15'688	2'403	6'158	23'403	6'608	7'010	9'823
3.3 Rent and running expenses of the platform m2 of surface		***1'919'464***	159'899	100'248	33'149	24'601	23'512	284'419	190'839	83'516	134'506	219'136	12'582	86'690	17'012	46'362	315'389	53'744	88'078	45'781
3.4 Others		***177'127***	19'079	9'886	2'011	5'883	638	18'590	29'012	12'810	8'042	26'219	887	19'441	2'317	4'349	10'104	92	6'220	1'548
Total indirect costs	CHF	***3'128'863***	230'625	166'521	69'958	64'422	78'891	373'935	368'291	145'192	175'837	355'815	22'686	205'489	33'489	84'441	443'373	82'686	134'734	92'478
Total yearly operational costs (OPEX)	CHF	***7'658'731***	524'772	687'069	179'447	218'357	165'687	853'457	919'531	468'779	318'410	826'241	54'076	524'411	110'938	247'455	895'214	131'989	351'980	180'918
Unit operational costs, CHF	Usage (h)	*A*	1'257	2'425	1'890	1'466	3'216	2'459	6'097	1'694	1'220	4'092	466	4'079	625	1'601	6'085	1'718	1'823	2'554
	Uptime (h)	*B*	4'756	6'261	7'715	5'091	10'024	3'042	13'384	7'878	19'849	11'756	8'647	8'556	2'815	11'800	23'916	10'604	11'974	27'722
U.1 Utilization cost 1 (direct costs)	CHF/h	*A*	80	126	44	74	24	68	39	76	43	56	37	37	49	55	56	20	69	23
U.2 Utilization cost 2 (direct costs + other direct costs)	CHF/h	*A&B*	120	160	47	83	25	171	62	101	48	77	38	56	65	61	60	21	77	24
U.3 Utilization cost 3 (direct costs + other direct costs + indirect costs)	CHF/h	*A&B*	169	187	56	96	33	294	90	120	57	107	41	80	77	69	79	29	88	28
Personnel of the common research facility	FTE	***19.1***																		
P.1 Operational		***51.6%***	3.1%	4.5%	2.2%	3.1%	1.6%	4.3%	4.9%	2.6%	1.2%	4.6%	0.4%	3.6%	1.0%	3.0%	6.0%	0.8%	2.8%	1.8%
P.2 Maintenance		***13.4%***	1.2%	0.7%	0.2%	0.3%	0.1%	1.8%	1.6%	0.7%	0.7%	1.6%	0.1%	1.0%	0.2%	0.4%	1.7%	0.3%	0.6%	0.3%
P.3 Administration		***32.3%***	1.8%	1.8%	1.0%	1.1%	1.6%	2.3%	4.7%	1.6%	1.1%	3.6%	0.3%	3.1%	0.4%	1.0%	3.5%	0.8%	1.3%	1.3%
P.4 Other		***2.6%***																		
Total		***100.0%***	6.0%	7.0%	3.4%	4.5%	3.3%	8.4%	11.2%	4.8%	3.0%	9.8%	0.8%	7.8%	1.6%	4.4%	11.3%	1.9%	4.7%	3.4%

FEES

- Since October 1st 2016
- **No** more **cap** per user and per month (previously CHF 1600.- / academic user / month)
- **No** more **free access** (for master & semester projects)
- 18 categories of tools (instead of uniform price per tool) :
  - with fees ranging from 20.- to 126.- CHF/h for internal EPFL Users
  - with fees ranging from 21.- to 171.- CHF/h for External Academic Users
  - with fees ranging from 30.8 to 323.40 CHF/h for Industrial Users

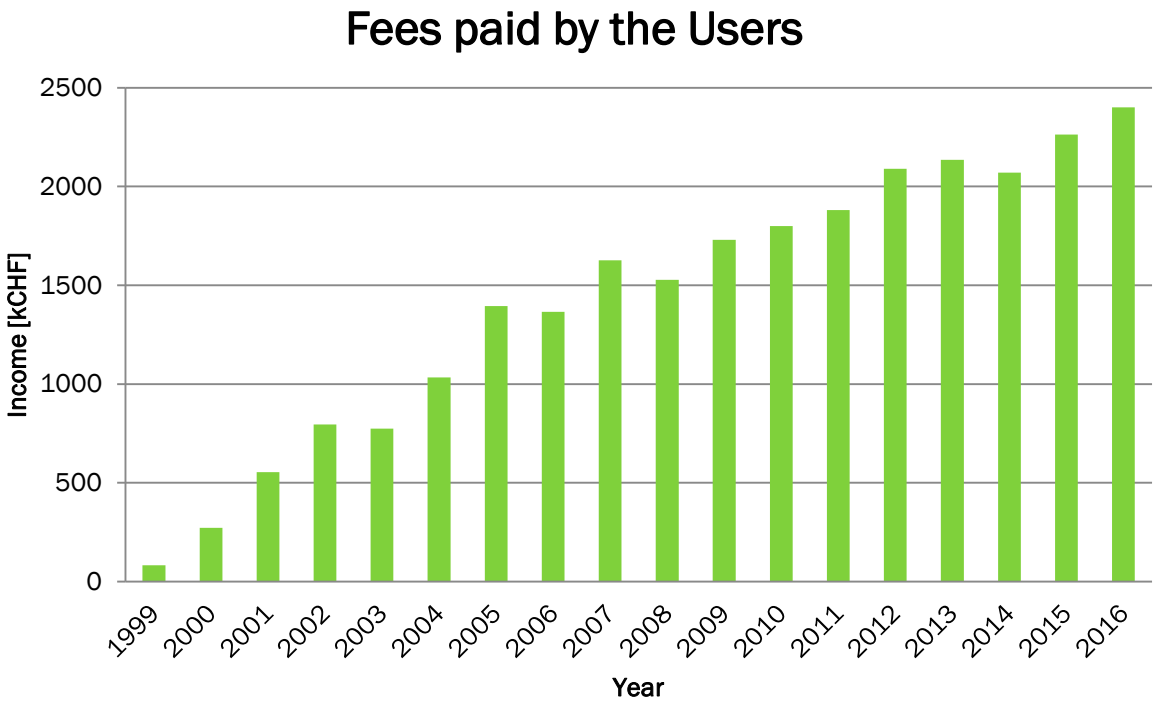
- In general new system cheaper for occasional users and more expensive for heavy users

- Globally no budget change for the operations of the CMi

FEES

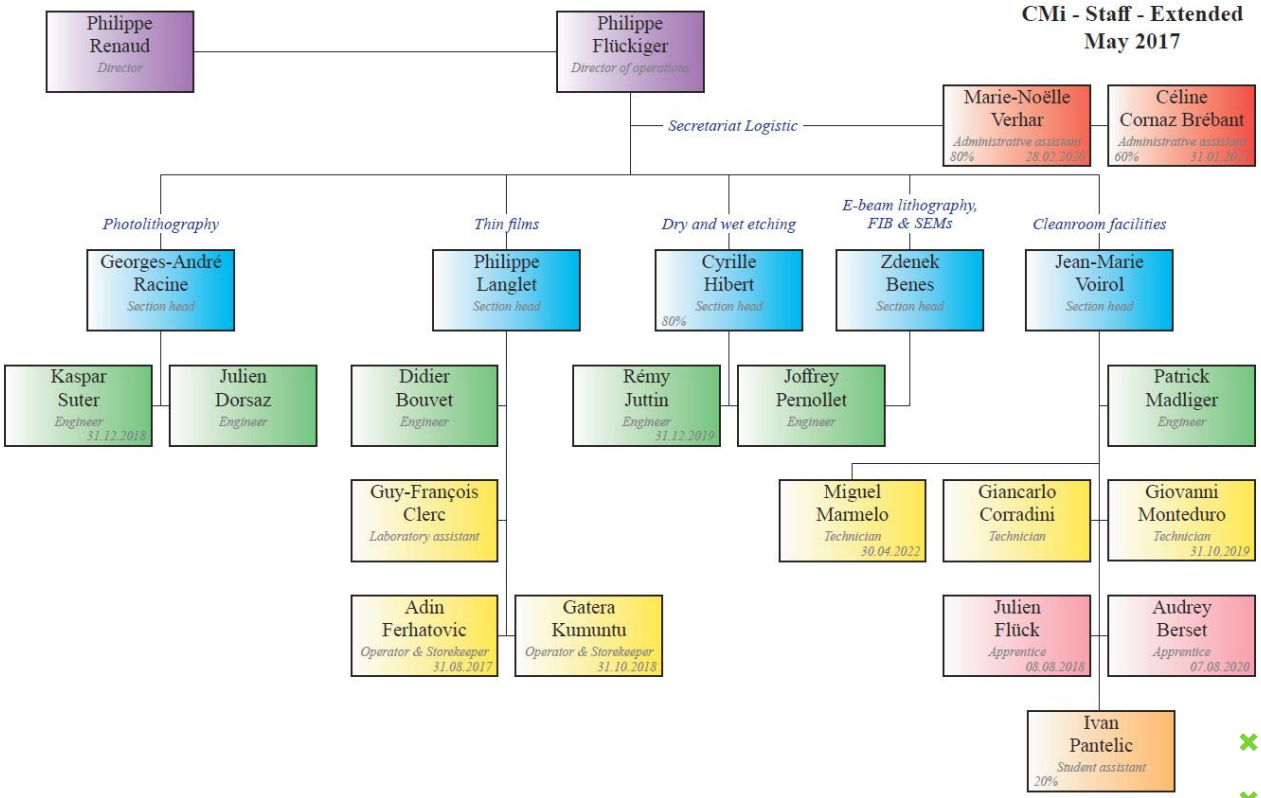
- Subsidies for master & semester projects
  - Up to CHF4k/master thesis project
  - Up to CHF1k/master semester project
  - Up to CHF0.5k/bachelor semester project
- Subsidies for lab projects - TBC
  - Funds possibly available for discovery lab projects that are beneficial to the technological development of CMi and its users' community

FEES



- The amount of the fees paid by the users is showing a regular progression since 1999
  - New fees system in place since October 1st 2016
  - Impact of the new system to be carefully monitored in the future

THE STAFF

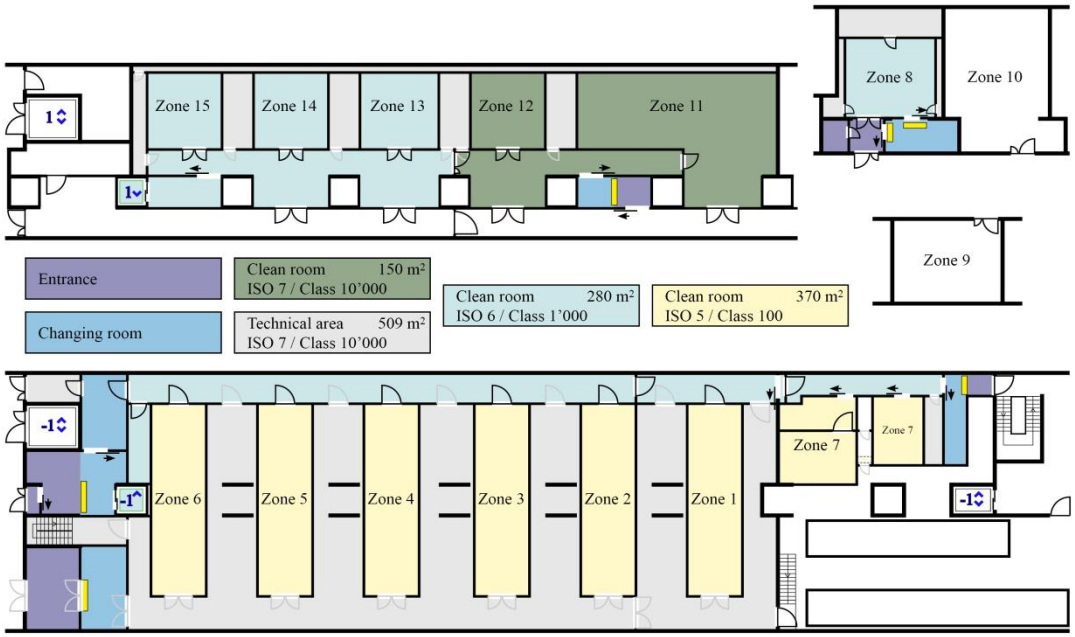


- 19.2 FTE staff members
- + Student assistants
- + Apprentices

CLEANROOM

- CMi BM+1

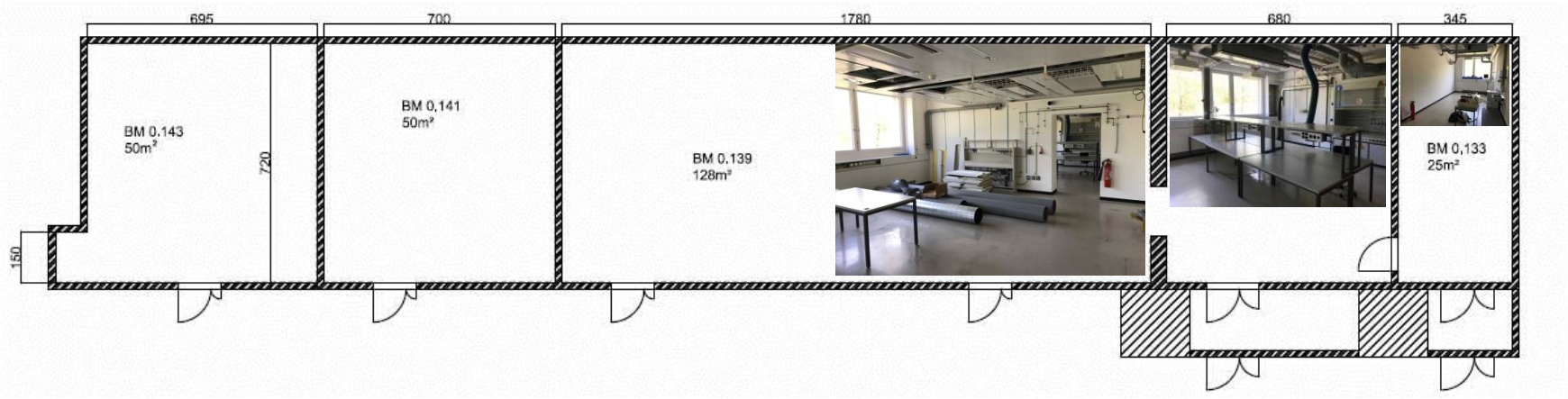
- CMi BM-1



Initial surface (1998)	Extension (2010)	Total surface
1000m^2	300m^2	1300m^2

- We have a total cleanroom surface of 1300m^2 on two levels connected by an elevator
- The cleanroom is getting very crowded
- New space is required for installing new tools

CLEANROOM



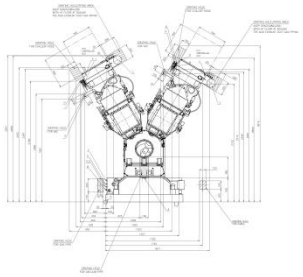
128/2+49+25=138m^2

Initial surface (1998)	Extension (2010)	Extension (2017)	Total surface
1000m^2	300m^2	138m^2	1438m^2

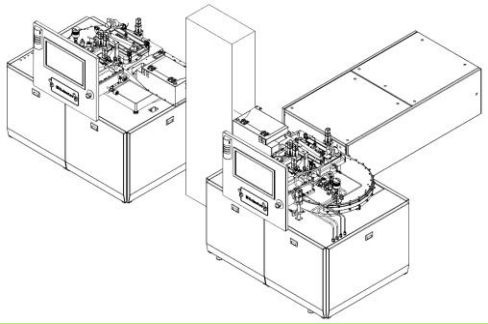
- 2017 Grey Room extension : 138m2

TOOLS INSTALLED/PURCHASED IN 2016

- Reactive Ion Etching system
  - TOKYO ELECTRON UNITY Me w/1 DRM & w/1 SCCM chamber
  - SNSF R'Equip Prof. Tobias Kippenberg
  - Low roughness SiO2 & Si3N4
  - High selectivity
  - High aspect ratio



- Pulsed Laser Deposition System
  - SOLMATES SMP800
  - 2 chambers
  - ERC Advanced Grant Prof. Adrian Ionescu
  - VO2, HfO2, Al2O3
  - PZT, LaNiO3



- ALD tool
  - BENEQ TFS200
  - SNSF R'Equip Prof. Jeremy Luterbacher
  - Coating of particles with Al2O3 TiO2 MgO
  - Deposition of magnetic materials(e.g. NiFe CoFe)
  - Delivery date : end of May 2017

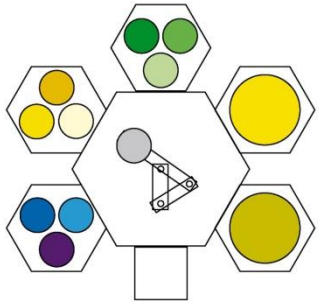
TOOLS INSTALLED/PURCHASED IN 2016

- Vapor HF release etcher
  - SPTS uEtch
  - R'Equip SNSF Prof. Niels Quack
  - Removal of sacrificial SiO2 layers to release silicon microstructures in MEMS devices

- Direct Laser Writer
  - Heidelberg Instruments MLA150
  - Acquired & upgraded in 2016
  - 2nd illumination & BSA
  - In beta site since August 2014

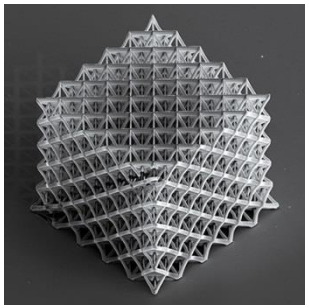
WHISH LIST FOR THE FUTURE ?

- Cluster Sputter Tool ?
  - Deposition of dielectric materials
  - Multilayers & Bragg reflectors
  - Co-sputtering of metals, nitrides & oxides



- EBEAM writer ? (and/or STEPPER ?)
  - Better performances
  - Speed, Image placement, Field size, Edge fracturing
  - Stability & Uniformity

- 3D Photolithography System



REQUESTS DIRECTLY FROM LABS ?

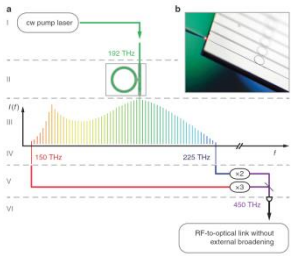
- High Density Plasma Enhanced Chemical Vapor Deposition System

- Chemical Mechanical Polishing System

PUBLICATIONS HIGHLIGHTS 2017

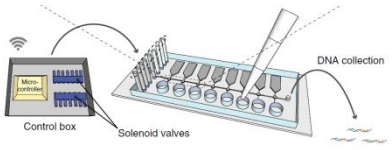
- A few examples of publications involving devices produced in CMi (during the last 12 months)

1°
Light: Science & Applications 13 January 2017
doi:10.1038/lsa.2016.202
Self-referenced photonic chip soliton Kerr frequency comb



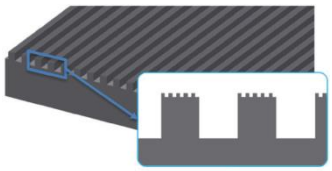
Frequency combs

2°
Nature Methods 16 January 2017
doi:10.1038/nmeth.4143
SMiLE-seq identifies binding motifs of single and dimeric transcription factors



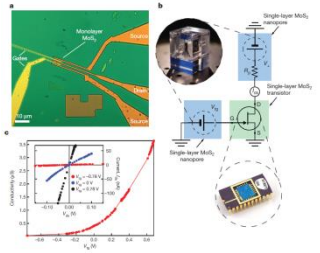
Genomic analysis

3°
Adv. Funct. Mater. 24 January 2017
doi:10.1002/adfm.201605935
Controlled Sub-Micrometer Hierarchical Textures Engineered in Polymeric Fibers and Microchannel Thermal Drawing



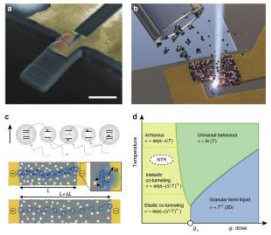
Fibers texturing

4°
Nature 13 July 2016
doi:10.1038/nature18593
Single-layer MoS2 nanopores as nanopower generators



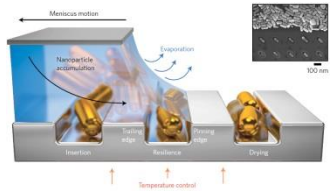
Self powered nanosystems

5°
Nature Communications 26 September 2016
doi:10.1038/ncomms12487
Direct-write nanoscale printing of nanogranular tunnelling strain sensors for sub-micrometre cantilevers



AFM cantilevers

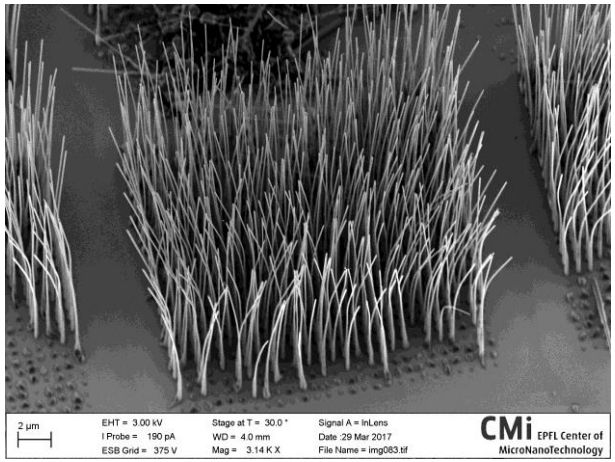
6°
Nature Nanotechnology 03 October 2016
doi:10.1038/nnano.2016.179
Nanoscale topographical control of capillary assembly of nanoparticles

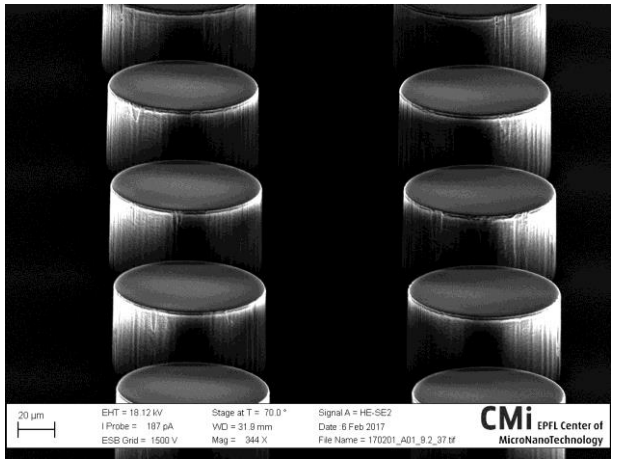


Assembly of nanoparticles

PICTURE OF THE MONTH - 2017

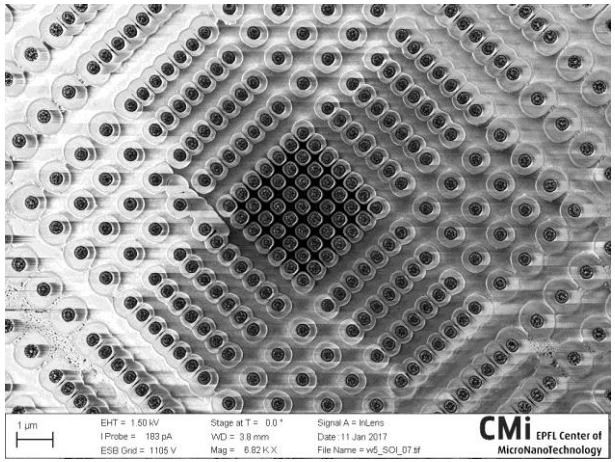
2017, March
G[r]aAs[s] Farming
Martin Friedl
LMSC

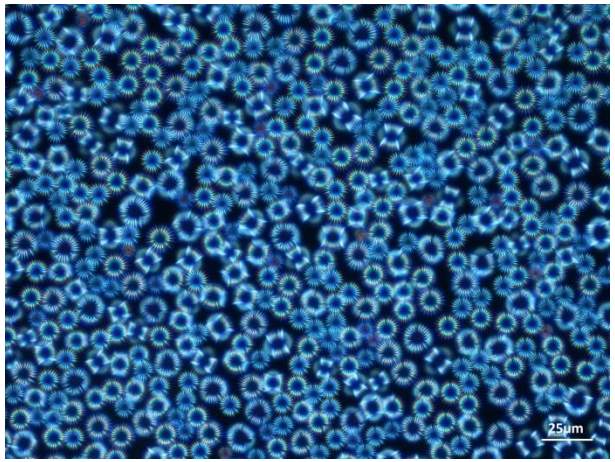




2017, February
Micro-lego-brick
Kevin Keim
CLSE

2017, January
Sushi boat
Stefano Varricchio,
LMIS4

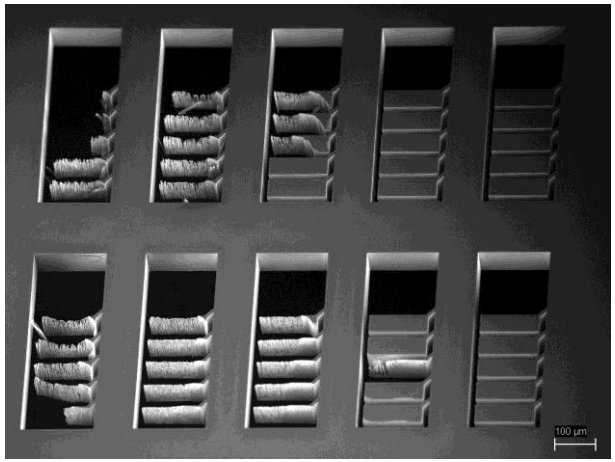


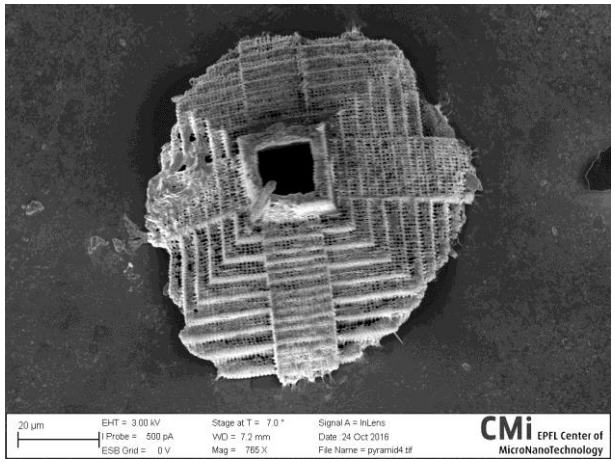


2016, December
Starry night
Benoît Desbiolles,
Clarisse Vaillier
LMIS4
Valentin Flauraud,
LMIS1

PICTURE OF THE MONTH - 2017

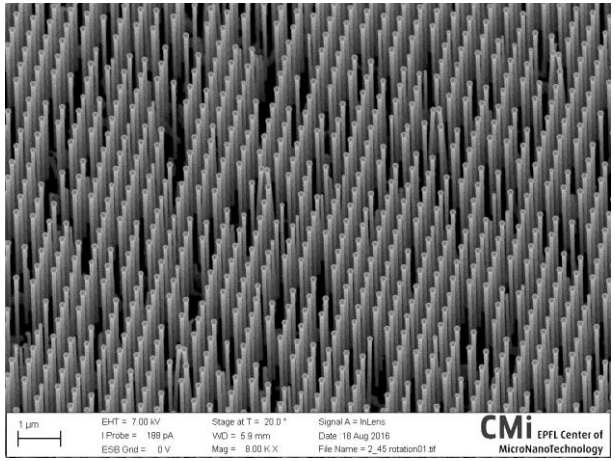
2016, November
Silicon Valley after an earthquake
Miloš Hrabovský,
Tescan





2016, October
The return of Quetzalcóatl
Edgar Emilio Morales Delgado,
LAPD

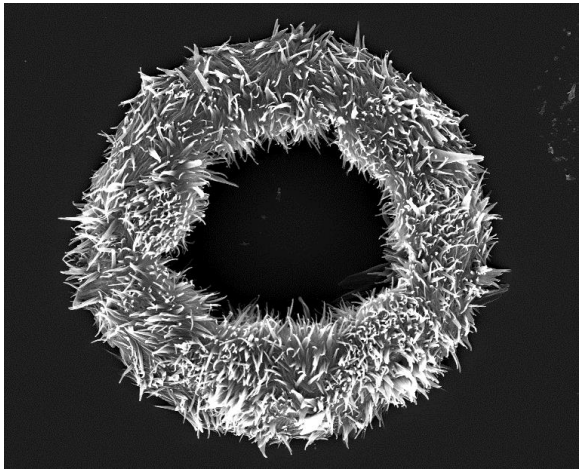
2016, September
A stroll in the village of Vik
Reza Soleiman,
POWERlab

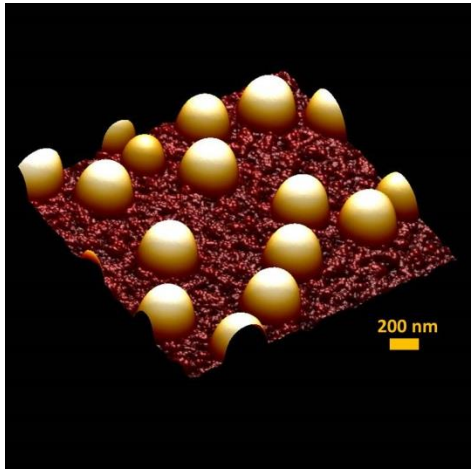


2016, August
Something between us
Wonjong Kim,
LMSC

PICTURE OF THE MONTH - 2017

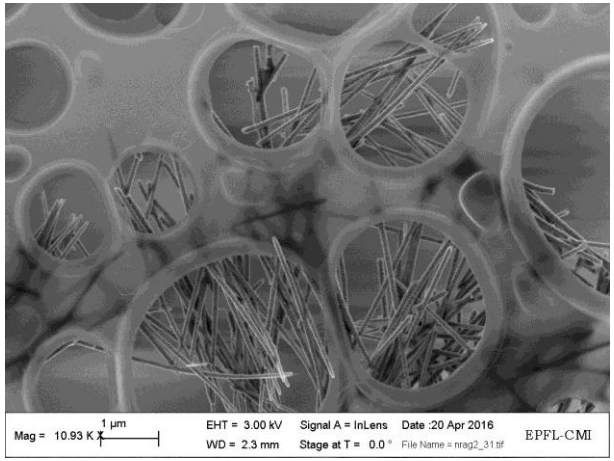
2016, July
Donut of thorns
Huachuan Du,
SMAL





2017, June
Dinosaurs are not extinct!
Wonjong Kim,
LMSC

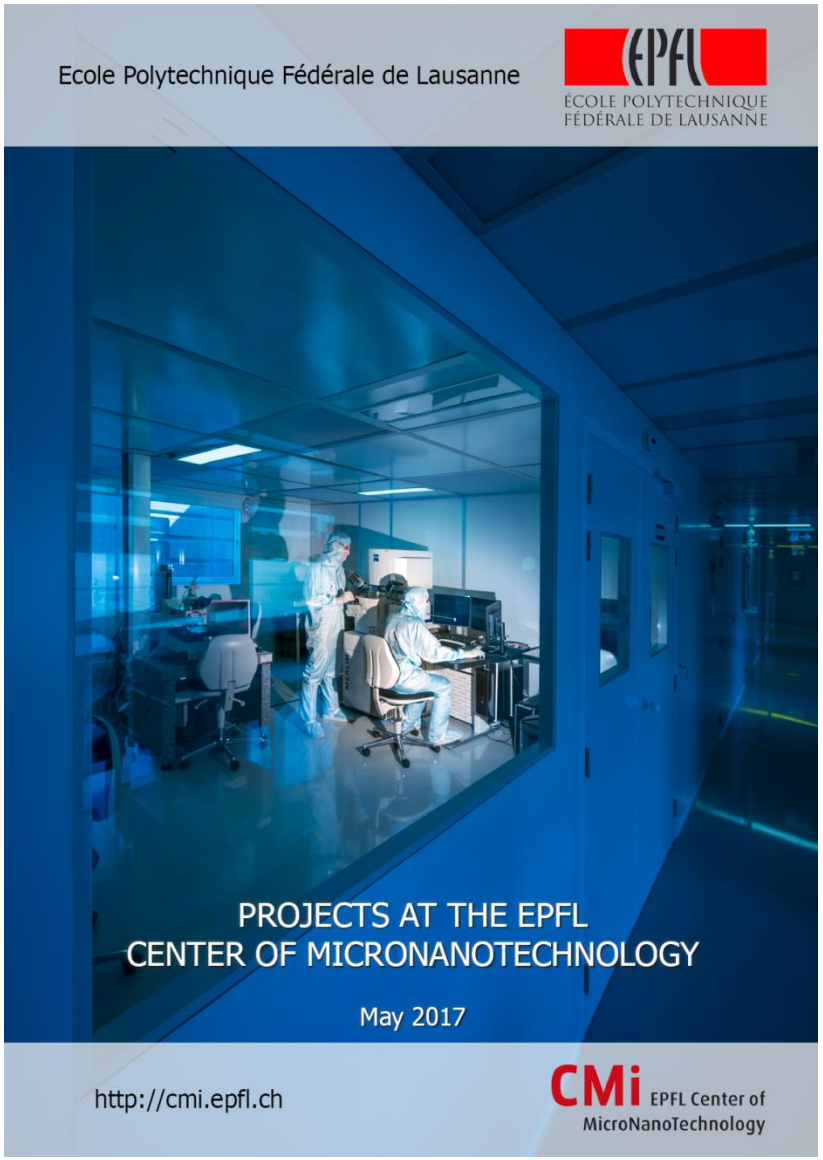
2016, May
Christmas card
Marta Airaghi Leccardi,
LNE



2016, April
See-through
Marco Negri,
LMSC

ABSTRACTS IN 2017

- 203 posters collected in the brochure



PROGRAM

- Very exciting program

- 10 presentations
- Spanning an exceptionally broad range
- Try to be different every year
- Not always invite the heavy users
- Emphasize on the new Professors @ EPFL
- Sometimes also some exotic users
- One common point:
  - MicroNanoFabrication

CMi EPFL Center of MicroNanoTechnology

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

MicroNanoFabrication Annual Review Meeting

Date: Tuesday May 2nd, 2017
Time: 09h30 – 17h00
Place: EPFL, Forum Rolex Learning Center, RLC E1 240

Program:

09h30-10h00	Coffees and Croissants, Distribution of Badges and Proceedings
10h00-10h15	***Philippe Renaud & Philippe Flückiger*** *(http://cmi.epfl.ch)*, Introduction
10h15-10h30	***Johannes Classen***, *(Robert Bosch GmbH, Reutlingen)*, Advanced surface micromachining process – a first step towards 3D MEMS
10h30-10h45	***Fabien Sorin***, *(http://fimap.epfl.ch)*, Scalable micro-fabrication over 2D substrates, fibers and fabrics via viscous flow engineering
10h45-11h00	***Stéphanie Lacour***, *(http://lsbi.epfl.ch)*, Engineering elasticity in thin film materials and devices
11h00-11h30	**Break**
11h30-11h45	***Bart Deplancke***, *(http://deplanckelab.epfl.ch)*, Microfluidic applications in regulatory genomics
11h45-12h00	***Georg Fantner***, *(http://lbni.epfl.ch)*, Hybrid multi layer MEMS devices for nano- and bio-sensing
12h00-12h15	***Nicolas Grandjean***, *(http://laspe.epfl.ch)*, III-nitride photonic crystal cavities
12h15-14h30	**Lunch & Poster Session**
14h30-14h45	***Erdem Alaca***, *(http://home.ku.edu.tr/~ealaca)*, Silicon nanowires: Monolithic fabrication in thick SOI and systems integration
14h45-15h00	***Adrian Ionescu***, *(http://nanolab.epfl.ch)*, Technologies for energy efficient computing and sensing at 100 mV
15h00-15h30	**Break**
15h30-15h45	***Valentin Flauraud***, *(http://lmis1.epfl.ch)*, Single digit nanofabrication to control light at the nanometer scale
15h45-16h00	***Michael Zervas***, *(http://www.ligentec.com)*, Silicon nitride photonic integrated circuits
16h00-17h00	**Cocktails & Poster Session**

ENJOY THE CONFERENCE

THANKS FOR YOUR ATTENTION