

Philippe Flückiger

14 May 2024



**EPFL
CMi** - Center of
MicroNanoTechnology

Philippe Flückiger

14 May 2024



EPFL

MicroNanoFabrication

Annual Review

Meeting

Philippe Flückiger, EPFL, May 14th, 2024

Next editions :

13.05.2025 – 24th edition

12.05.2026 – 25th edition

11.05.2027 – 26th edition

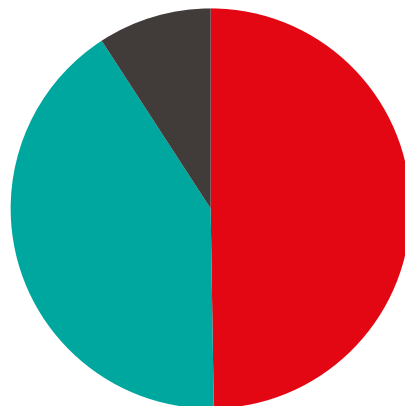
09.05.2028 – 27th edition

08.05.2029 – 28th edition

Welcome & thanks

- Welcome to the 23rd edition of the CMi MicroNanoFabrication Annual Review Meeting
- 796 participants registered (with 40% from industry and 50% from EPFL)
- Many thanks for your participation

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



■ EPFL 396 49.7%

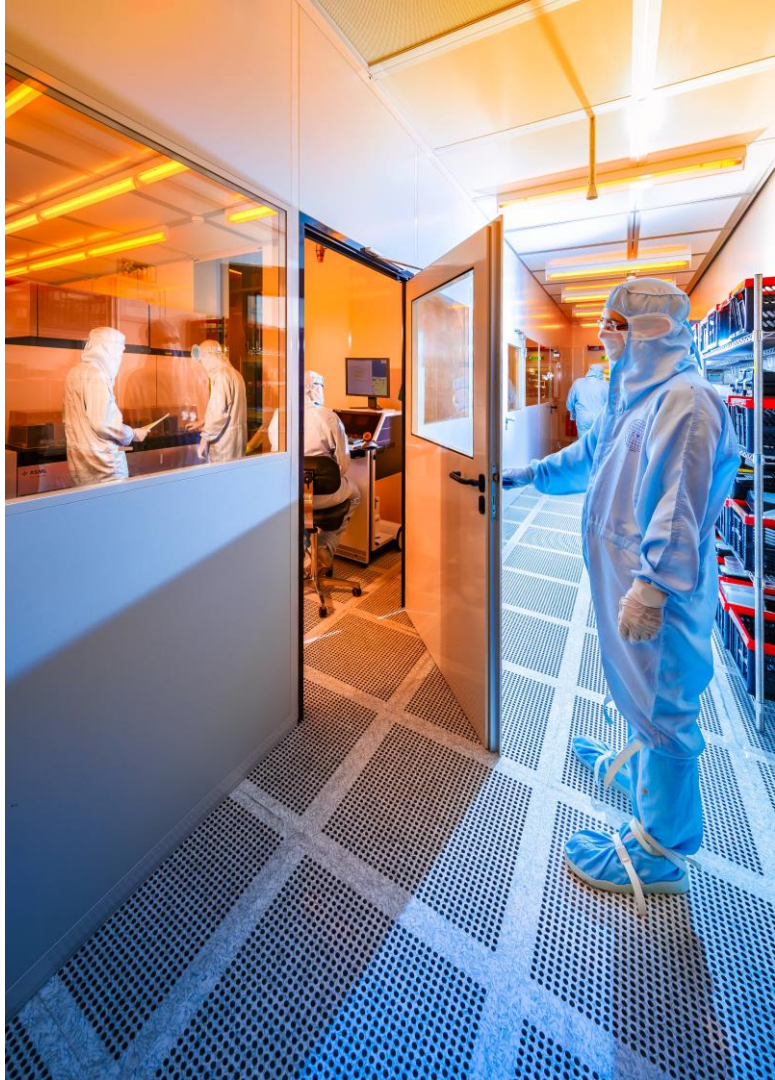
■ Industry 327 41.1%

■ Academic 73 9.2%

Countries	
	710 (89.2%)
	28 (3.52%)
	26 (3.27%)
	8 (1.01%)
	6 (0.75%)
	4 (0.5%)
	3 (0.38%)
	3 (0.38%)
	2 (0.25%)
	1 (0.13%)
	1 (0.13%)
	1 (0.13%)
	1 (0.13%)
	1 (0.13%)
	1 (0.13%)

- The list of participants is available to everyone
- Traveling from 15 different countries
- Fantastic opportunity for networking





CMi at glance

Users

Finances

Governance

Staff

Tools

Cleanroom

Projects

Users in 2023

Engineering Sc.		Basic Sc.	Life Sc.	Ext. Acad.		Companies		
STI-IBI-BIOS	STI-IEM-PHOSL	SB-IPHYS-GR-GA	SV-GHI-UPKIN	AMI_FR_BioPhysics	UNIGE_GAP	ABC_Lab	Ligentec	Rolex_Bienne
STI-IBI-CLSE	STI-IEM-POWERLAB	SB-IPHYS-HQC	SV-GHI-UPPERSAT	CERN_BE_dept	UNIGE_Physique	ActLight	Limula	Safran_Sensing
STI-IBI-LBEN	STI-IEM-PV-LAB	SB-IPHYS-LASPE	SV-IBI-UPDEPLA	CERN_EP_dept	UNIL	Adaptivv_Biosystem	Lionix_Intl	SEED
STI-IBI-LBMM	STI-IEM-SCI-SC	SB-IPHYS-LEB	SV-IBI-UPLUT	CSEM_T1	UNIL_ISTE	Advanced_Fiber_Re	LSPR	Sensirion
STI-IBI-LBNC	STI-IGM-EMSI	SB-IPHYS-LMSC2	SV-ISREC-UPBRI	CSEM_T4	UNI-SUSSEX-PH-IQT	Aleva	Lumiphase	Sigatec
STI-IBI-LBNI	STI-IGM-ETA-LAB	SB-IPHYS-LNS	SV-ISREC-UPORICCHIO	CSEM_T5		Alpes_Lasers	Lunaphore	Silicon_Austria_7
STI-IBI-LNE	STI-IGM-LMTS	SB-IPHYS-LPBS	SV-PTECH-PTBET	CSEM_V1		AMO	Luxtelligence	Silicon_Austria_9
STI-IBI-TNE	STI-IGM-LNET	SB-IPHYS-LPL	SV_SSV-TP1	CSEM-Allschwil		Annaida	Mackinac	SoHHytec
STI-IEL-GR-SCI	STI-IGM-LRESE	SB-IPHYS-LPQM1		CSEM-Muttentz_Cent		ArcoScreen	MCH-processing	Sunbioscience
STI-IEL-INL	STI-IGM-MICROBS	SB-IPHYS-LQM		ECAL		Axetris	Meister-Abrasive	SwissflexMicro
STI-IEM-ALCHEMY	STI-IGM-NEMS	SB-IPHYS-LQP		Eidikos_Logariasm		Bloesch	Melexis	Swistor
STI-IEM-AQUA	STI-IMX-FIMAP	SB-IPHYS-LUMES		ETHZ_D-BSSE_BEL		Bruker	Microcrystal	SYANDSE
STI-IEM-GALATEA	STI-IMX-INE	SB-IPHYS-SQIL	Computer & Communication	ETHZ_D-BSSE_QDB		Confovris	MicroR_Systems	XeedQ
STI-IEM-HYLAB	STI-IMX-LMGN	SB-ISIC-LAS	IC-IINFCOM-SENS	ETHZ_D-ITET_IDEAS		Corintis	Miraex	XRnanotech
STI-IEM-ICLAB	STI-IMX-LMSC	SB-ISIC-LIMNO		ETHZ_D-MAVT_MNS		Creal	Mistic	Xsensio
STI-IEM-LAFT	STI-IMX-LP	SB-ISIC-LND		ETHZ_D-MAVT_Nanop		Deeplight	Morphotonix	
STI-IEM-LAI	STI-IMX-SMAL	SB-ISIC-LPDC		ETHZ_D-PHYS_LFKP		Doppl	Nanoga	
STI-IEM-LANES	STI-INX-LSBI	SB-ISIC-LPI		HES-SO-GE_inSTI		Enlightra	Nanoworld	
STI-IEM-LAPD	STI-SCI-AXS	SB-ISIC-LSCI	Civil Engineering	HES-SO-NE_HEARC		EXALOS	Novagan	
STI-IEM-LMIS1	STI-SCI-JVH	SB-SCI-RH	ENAC-GE	Metas		FEMTOprint	Oxford_Ionics	
STI-IEM-LMIS2	STI_SEL	SB-SPC-II	ENAC-IIIE-LGB	PSI_LSB		Freshape	Parithera	
STI-IEM-LMIS4	STI_SMT-TP1	SB-SPH-GE		UCLouvain_IMMC		GB_Microfab	Pi_Imaging	
STI-IEM-LO	STI_SMT-TP2			UNI_Tokyo		Gersteltec	Piemacs	
STI-IEM-LPMAT				UNIBAS		Hexisense	Q_Ant	
STI-IEM-LPQM2				UNIBAS_2		ID_Quantique	Richemont	
STI-IEM-NAM				UNIFR_Chemistry		Imina	Roche-ITB	
STI-IEM-NANOLAB				UNIGE_DPNC		Infrascreen	Rolex	
50 (309)		22 (100)	11 (23)	32 (53)		69 (134)		


 # of laboratories
 # of users

- Total: 563 users belonging to 184 laboratories or companies
- Each cell represents a laboratory headed by a Professor (STI/SB/SV/IC/ENAC)

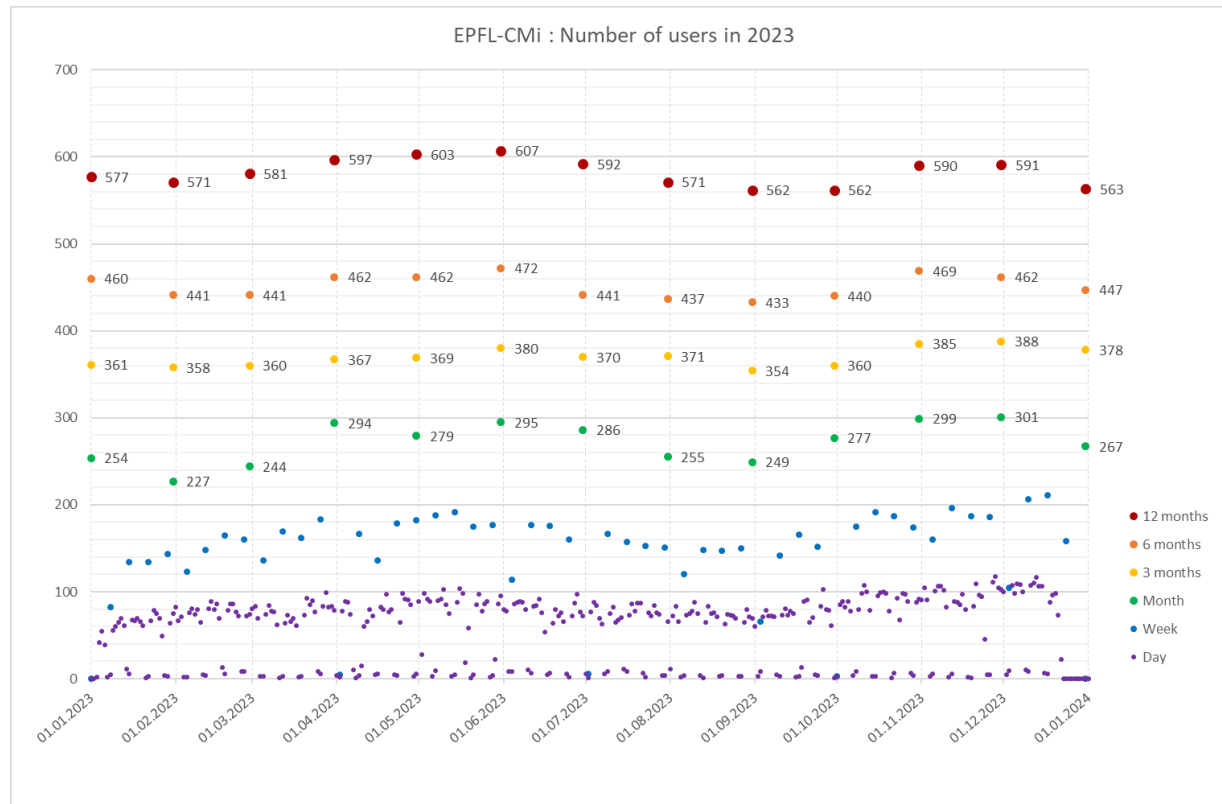
Users in 2023

Engineering Sc.		Basic Sc.	Life Sc.	Ext. Acad.		Companies		
STI-HI-BIOS	STI-IEM-PHOSL	SB-IPHYS-GR-GA	SV-GHI-UPKIN	AMI_FR_BioPhysics	UNIGE_GAP	ABC_Lab	Ligentec	Rolex_Bienne
STI-HI-CLSE	STI-IEM-POWERLAB	SB-IPHYS-HQC	SV-IPHYS-PERSAT	CERN_BE_dept	UNIGE_Physique	ActLight	Limula	Safran_Sensing
STI-HI-LBEN	STI-IEM-PV-LAB	SB-IPHYS-LASPE	SV-IPHYS-LEB	CERN_EP_dept	UNIL	Adaptivv_Biosystem	Lionix_Intl	SEED
STI-HI-LBMM	STI-IEM-SCI-SC	SB-IPHYS-LEB	SV-IPHYS-LEB	CSEM_T1	UNIL_ISTE	Advanced_Fiber_Re	LSPR	Sensirion
STI-HI-LBNC	STI-IGM-EMSI	SB-IPHYS-LMSC2	SV-IPHYS-LMSC2	CSEM_T4	UNI-SUSSEX-PH-IQT	Aleva	Lumiphase	Sigatec
STI-HI-LBNC	STI-IGM-EMSI	SB-IPHYS-LMSC2	SV-IPHYS-LMSC2	CSEM_T5		Alpes_Lasers	Lunaphore	Silicon_Austria_7
STI-HI-LBNC	STI-IGM-EMSI	SB-IPHYS-LMSC2	SV-IPHYS-LMSC2	CSEM_V1		AMO	Luxtelligence	Silicon_Austria_9
STI-HI-LBNC	STI-IGM-EMSI	SB-IPHYS-LMSC2	SV-IPHYS-LMSC2	CSEM-Allschwil		Annaida	Mackinac	SoHHytec
STI-HI-LBNC	STI-IGM-EMSI	SB-IPHYS-LMSC2	SV-IPHYS-LMSC2	CSEM-Muttentz_Cent		ArcoScreen	MCH-processing	Sunbioscience
STI-HI-LBNC	STI-IGM-EMSI	SB-IPHYS-LMSC2	SV-IPHYS-LMSC2	ECAL		Axetris	MCH-processing	SwissflexMicro
STI-HI-LBNC	STI-IGM-EMSI	SB-IPHYS-LMSC2	SV-IPHYS-LMSC2	Eidikos_Logan		Bloesch	MCH-processing	Swistor
STI-HI-LBNC	STI-IGM-EMSI	SB-IPHYS-LMSC2	SV-IPHYS-LMSC2	ETHZ_D-BSS		Bruker	MCH-processing	SYANDSE
STI-HI-LBNC	STI-IGM-EMSI	SB-IPHYS-LMSC2	SV-IPHYS-LMSC2	ETHZ_D-BSS		Confovris	MCH-processing	XeedQ
STI-HI-LBNC	STI-IGM-EMSI	SB-IPHYS-LMSC2	SV-IPHYS-LMSC2	ETHZ_D-ITET		Corintis	MCH-processing	XRnanotech
STI-HI-LBNC	STI-IGM-EMSI	SB-IPHYS-LMSC2	SV-IPHYS-LMSC2	ETHZ_D-MAVT_MNS		Creal	MCH-processing	Xsensio
STI-HI-LBNC	STI-IGM-EMSI	SB-IPHYS-LMSC2	SV-IPHYS-LMSC2	ETHZ_D-MAVT_Nanop		Deeplight	Morphotonix	
STI-HI-LBNC	STI-IGM-EMSI	SB-IPHYS-LMSC2	SV-IPHYS-LMSC2	ETHZ_D-PHYS_LFKP		Doppl	Nanoga	
STI-HI-LBNC	STI-IGM-EMSI	SB-IPHYS-LMSC2	SV-IPHYS-LMSC2	HES-SO-GE_inSTI		Enlightra	Nanoworld	
STI-HI-LBNC	STI-IGM-EMSI	SB-IPHYS-LMSC2	SV-IPHYS-LMSC2	HES-SO-NE_HEARC		EXALOS	Novagan	
STI-HI-LBNC	STI-IGM-EMSI	SB-IPHYS-LMSC2	SV-IPHYS-LMSC2	Metas		FEMTOprint	Oxford_Ionics	
STI-HI-LBNC	STI-IGM-EMSI	SB-IPHYS-LMSC2	SV-IPHYS-LMSC2	PSI_LSB		Freshape	Parithera	
STI-HI-LBNC	STI-IGM-EMSI	SB-IPHYS-LMSC2	SV-IPHYS-LMSC2	UCLouvain_IMMC		GB_Microfab	Pi_Imaging	
STI-HI-LBNC	STI-IGM-EMSI	SB-IPHYS-LMSC2	SV-IPHYS-LMSC2	UNI_Tokyo		Gersteltec	Piemacs	
STI-HI-LBNC	STI-IGM-EMSI	SB-IPHYS-LMSC2	SV-IPHYS-LMSC2	UNIBAS		Hexisense	Q_Ant	
STI-HI-LBNC	STI-IGM-EMSI	SB-IPHYS-LMSC2	SV-IPHYS-LMSC2	UNIBAS_2		ID_Quantique	Richemont	
STI-HI-LBNC	STI-IGM-EMSI	SB-IPHYS-LMSC2	SV-IPHYS-LMSC2	UNIFR_Chemistry		Imina	Roche-ITB	
STI-HI-LBNC	STI-IGM-EMSI	SB-IPHYS-LMSC2	SV-IPHYS-LMSC2	UNIGE_DPNC		Infrascreen	Rolex	
50 (309)		22 (100)	11 (23)	32 (53)		69 (134)		

↑
of laboratories

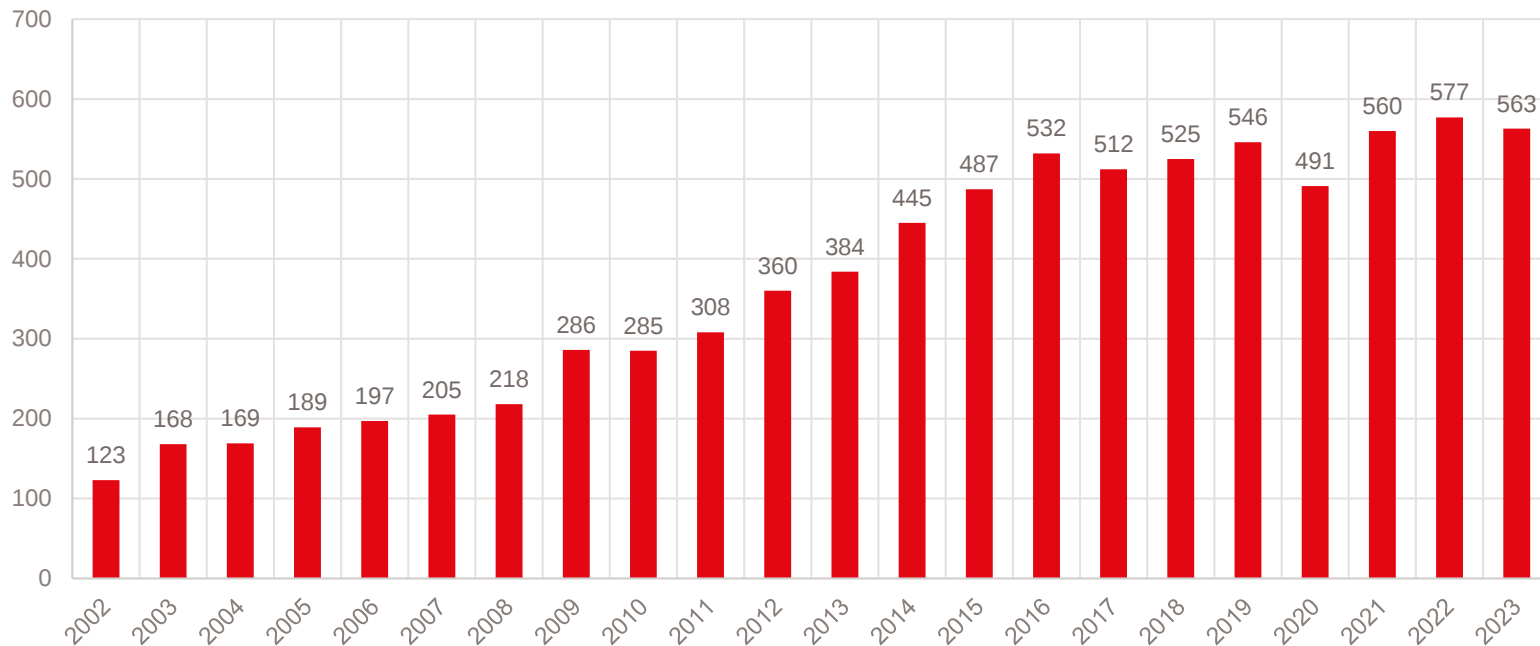
↑
of users

- The EPFL laboratories using the CMi belong to 10 EPFL institutes
- External : CERN CSEM EMPA ETHZ UNI (CH and other) + Small SME Global

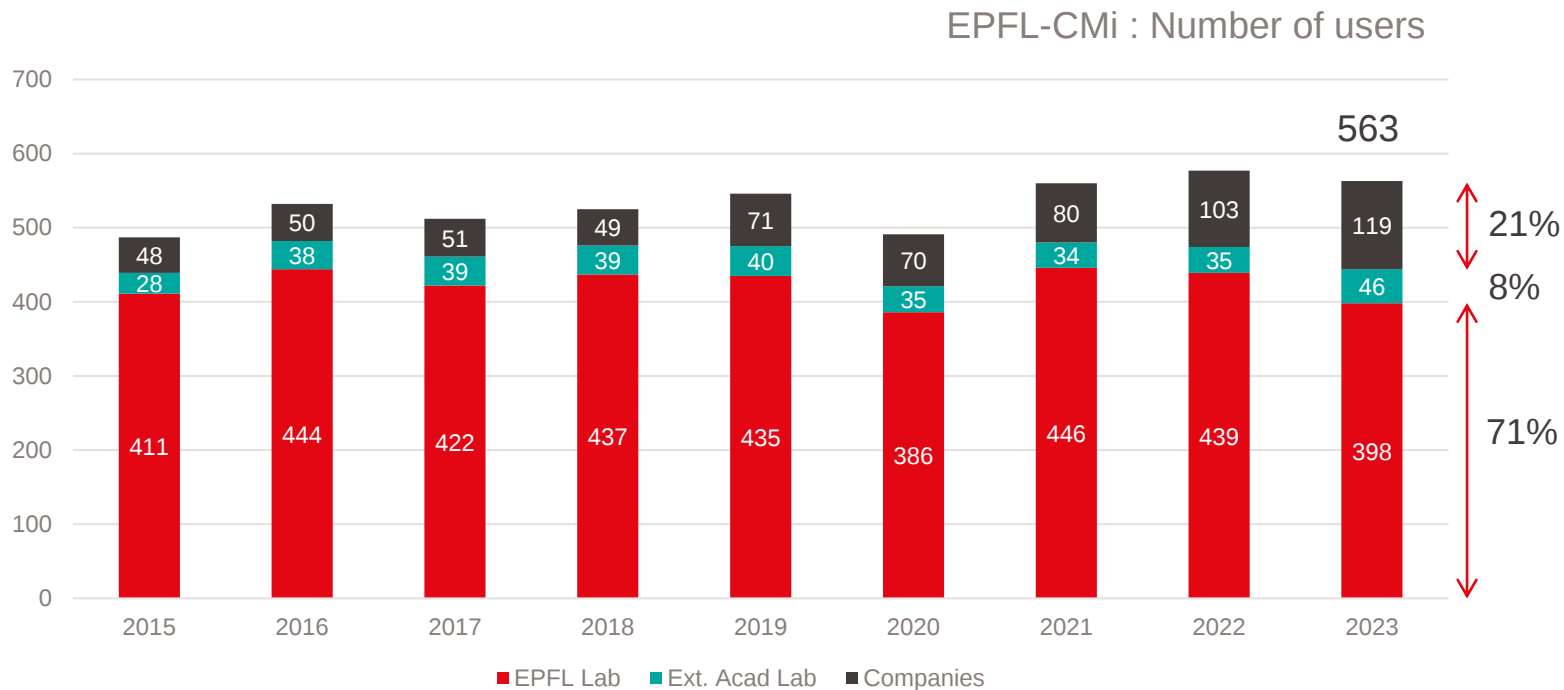
600 / 12 months 300 / month 200 / week 100 / day 

- The number of users is rather stable over the year

EPFL-CMi : Number of users

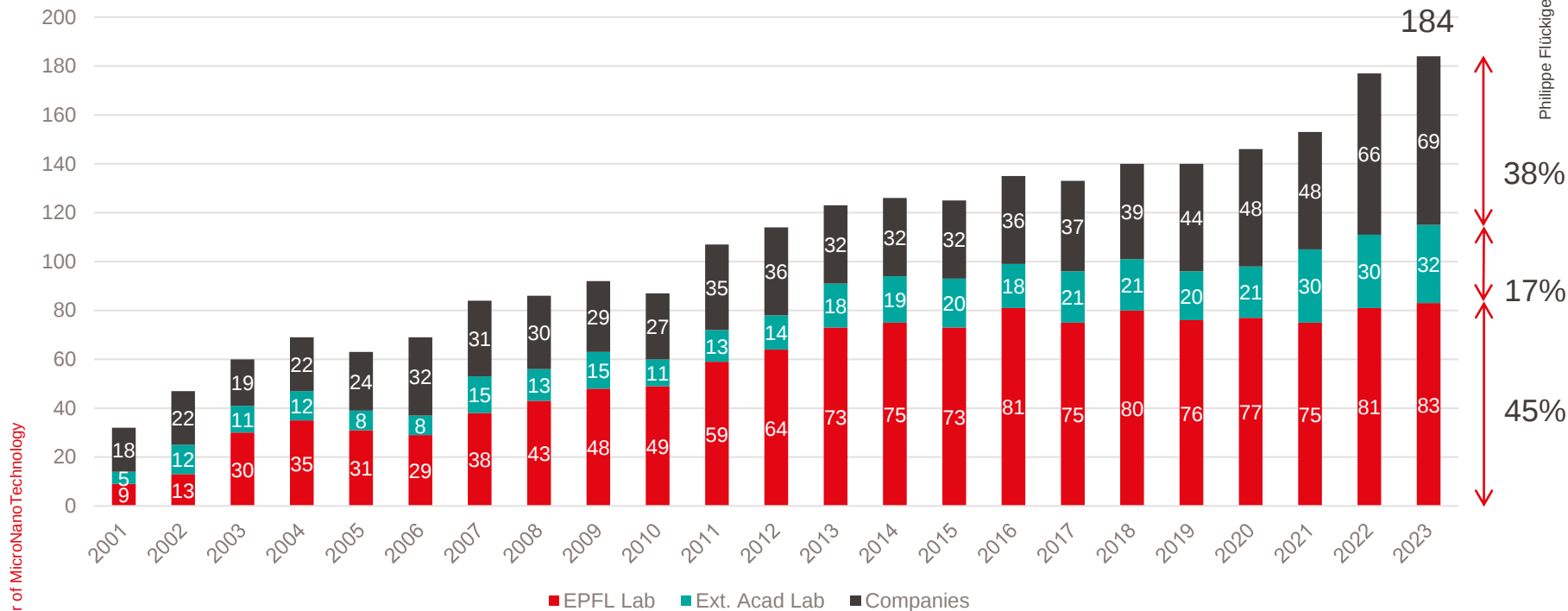


- Evolution of the number of users over the years since 2002
- From 100 to 600 users



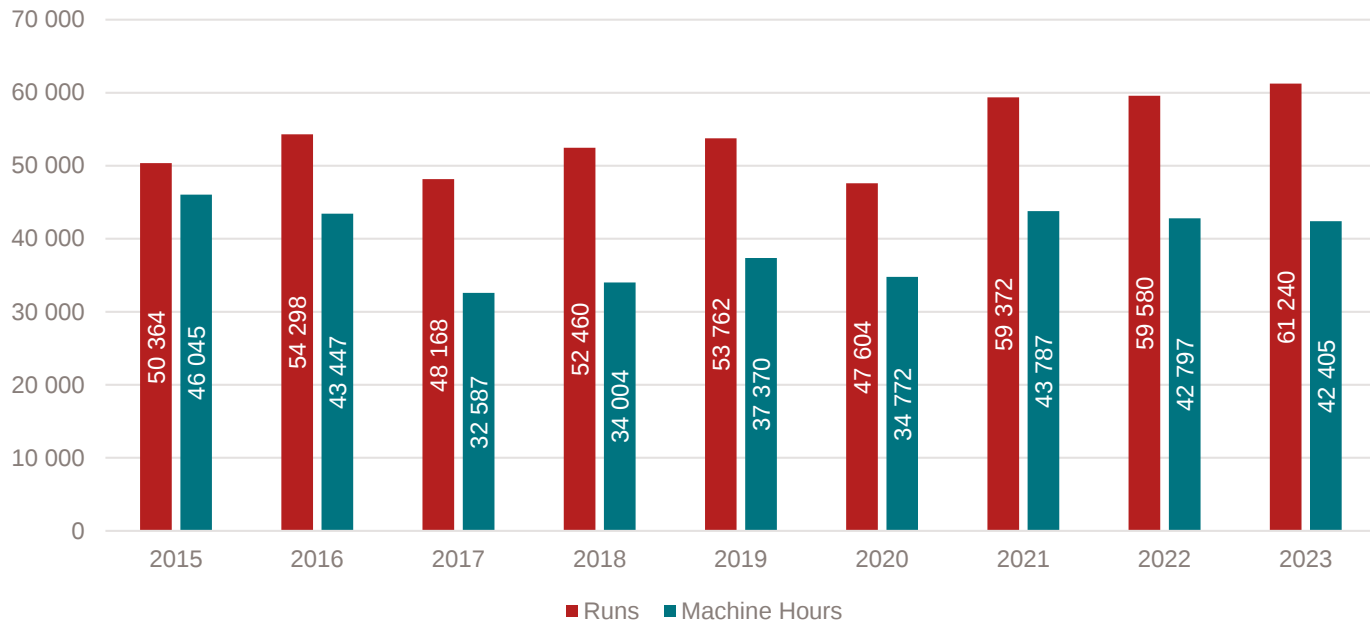
- The number of users per affiliation since 2015
- 71% of our users are from EPFL and 21% are from industry

EPFL-CMi : Number of clients



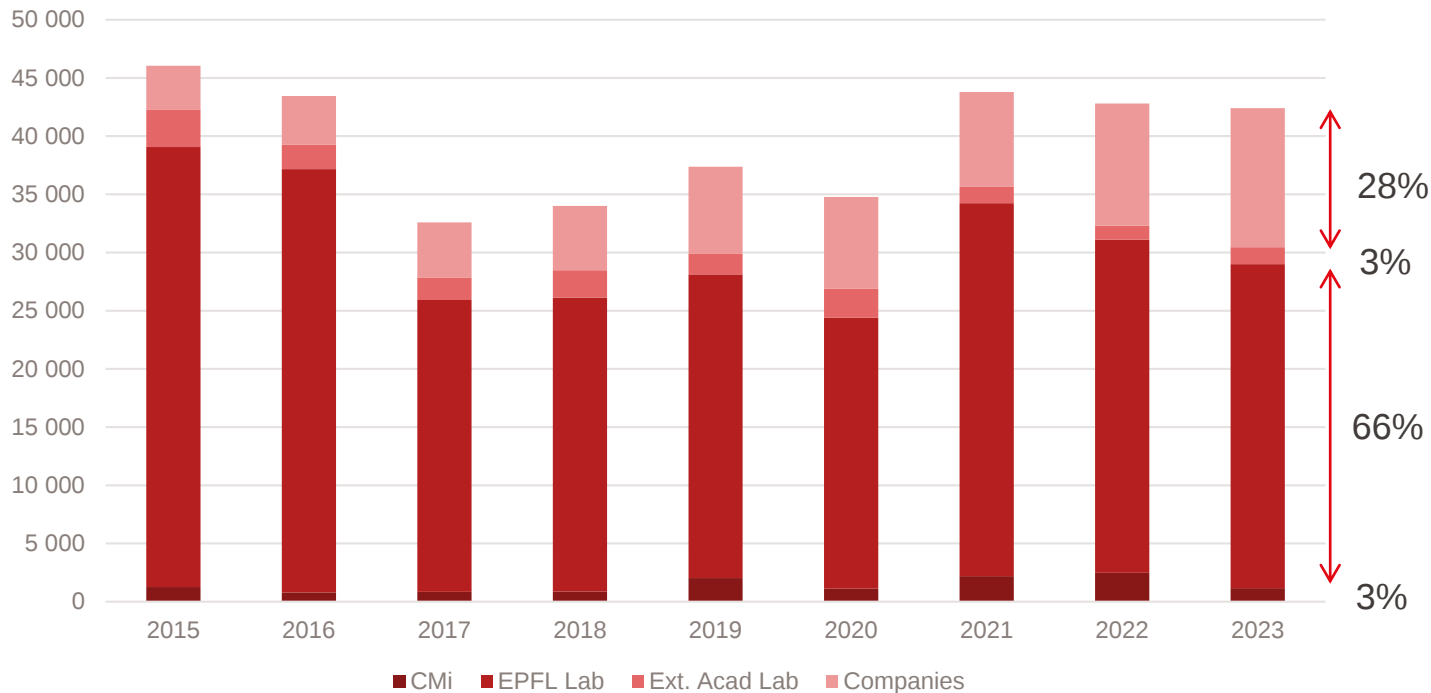
- The number of clients per affiliation since 2001
- Client = EPFL Labs, External Academic Labs, Companies

EPFL-CMi : Usage



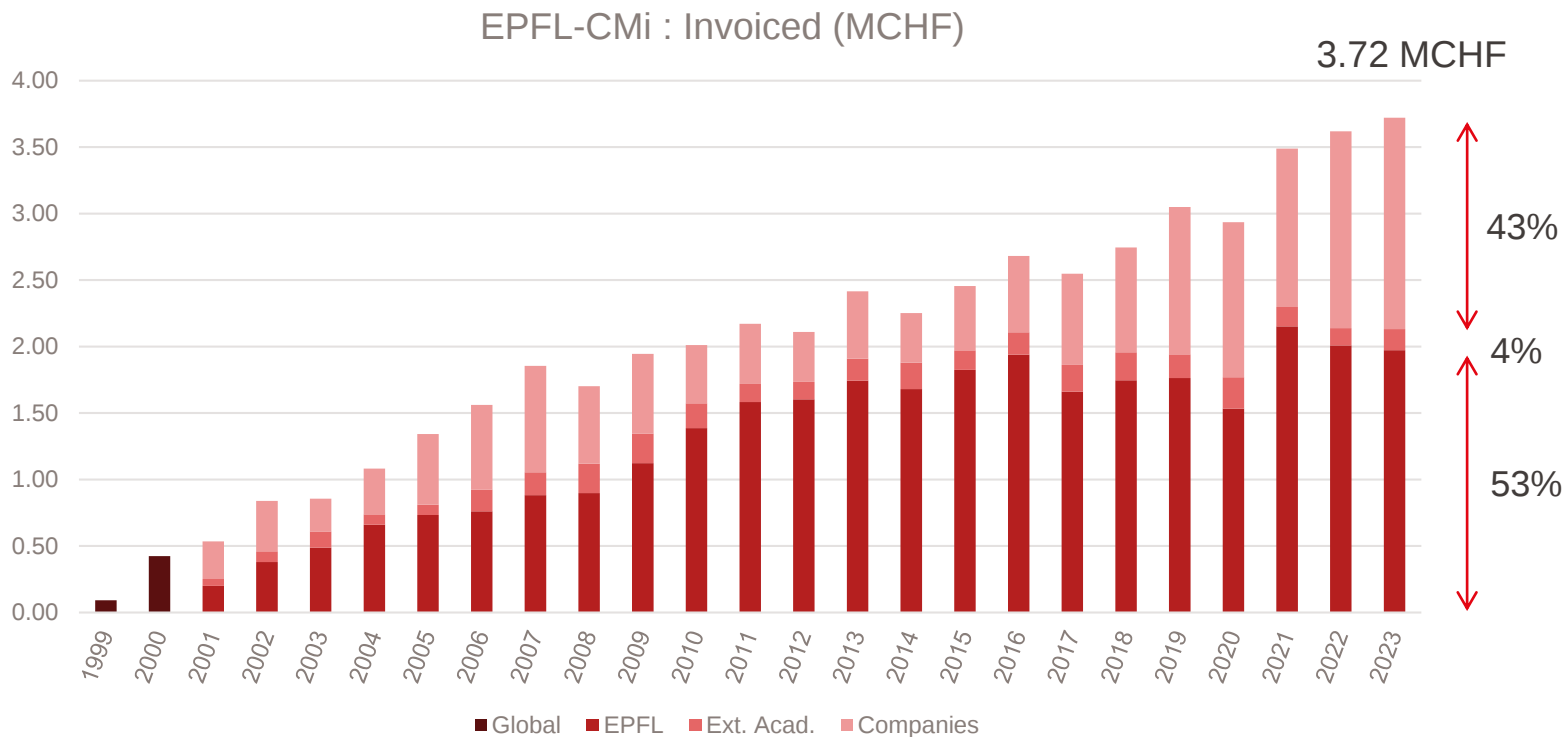
- The users generated 61 thousand runs and 42'00 machine hours in 2023

EPFL-CMi : Billed Machine Hours



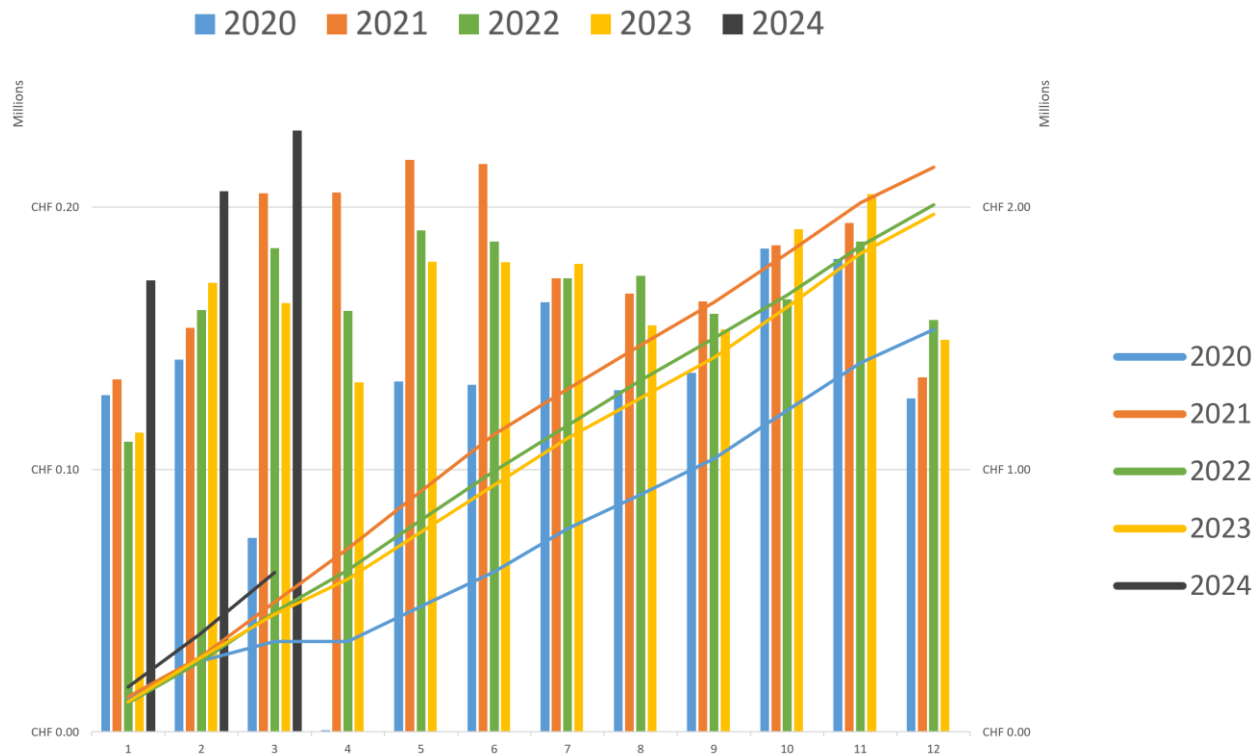
- 66% of the machine hours were billed to EPFL users and 28% to industry

Invoicing in 2023



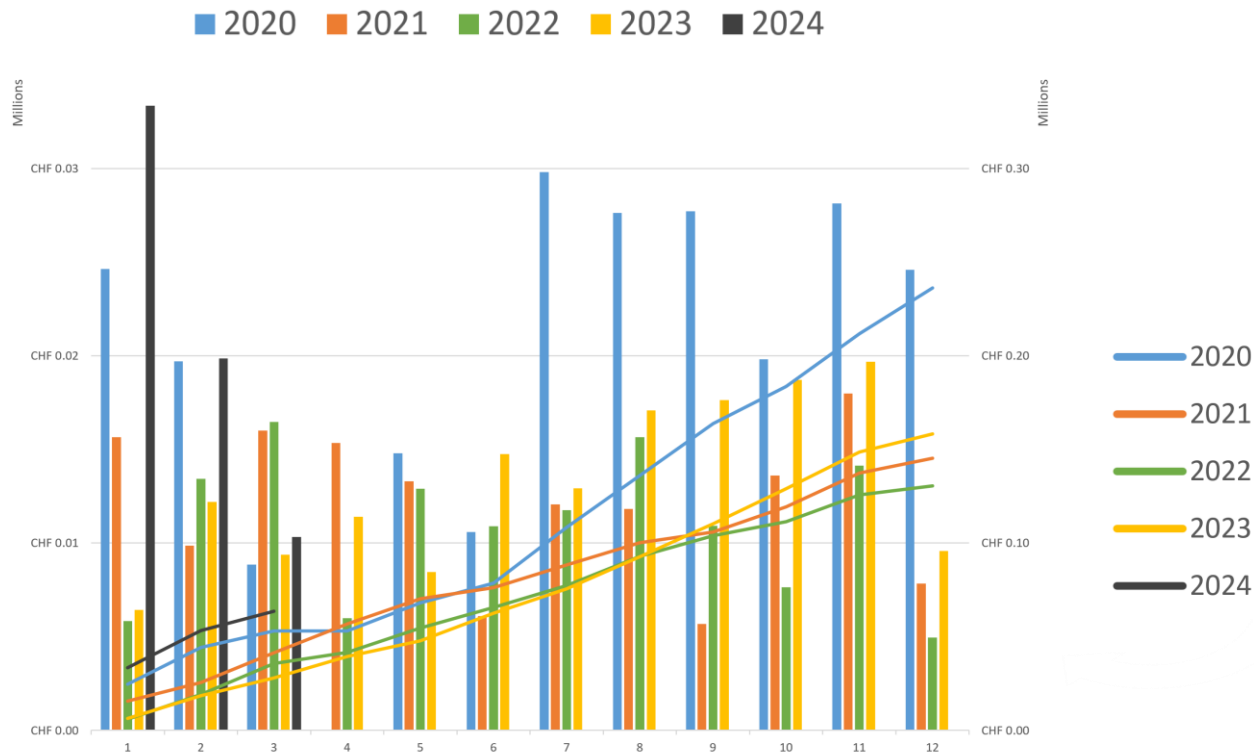
- 3.7 millions CHF were billed to our users in 2023
- 53% were paid by EPFL users and 43% were paid by our industrial users

Invoicing to internal EPFL Users



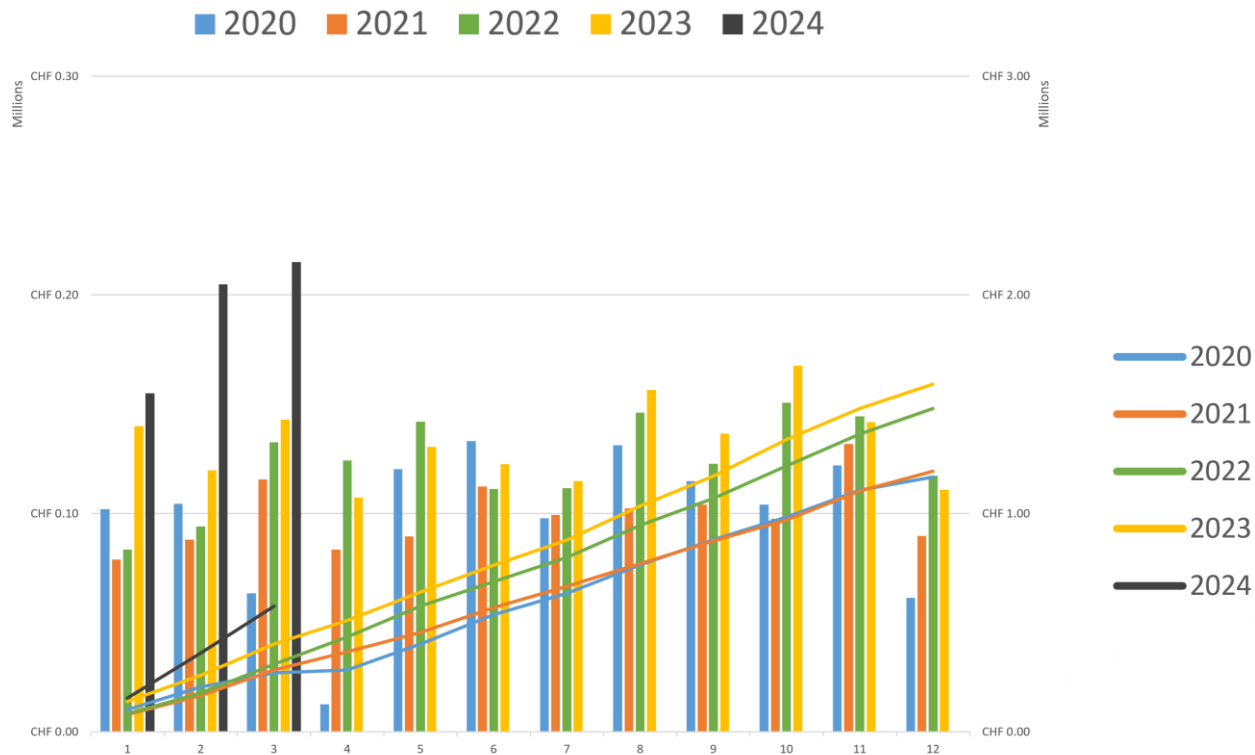
- The monthly invoicing to the users shows that 2024 is starting well
- Internal EPFL users (53% of our revenues)

Invoicing to external academic Users



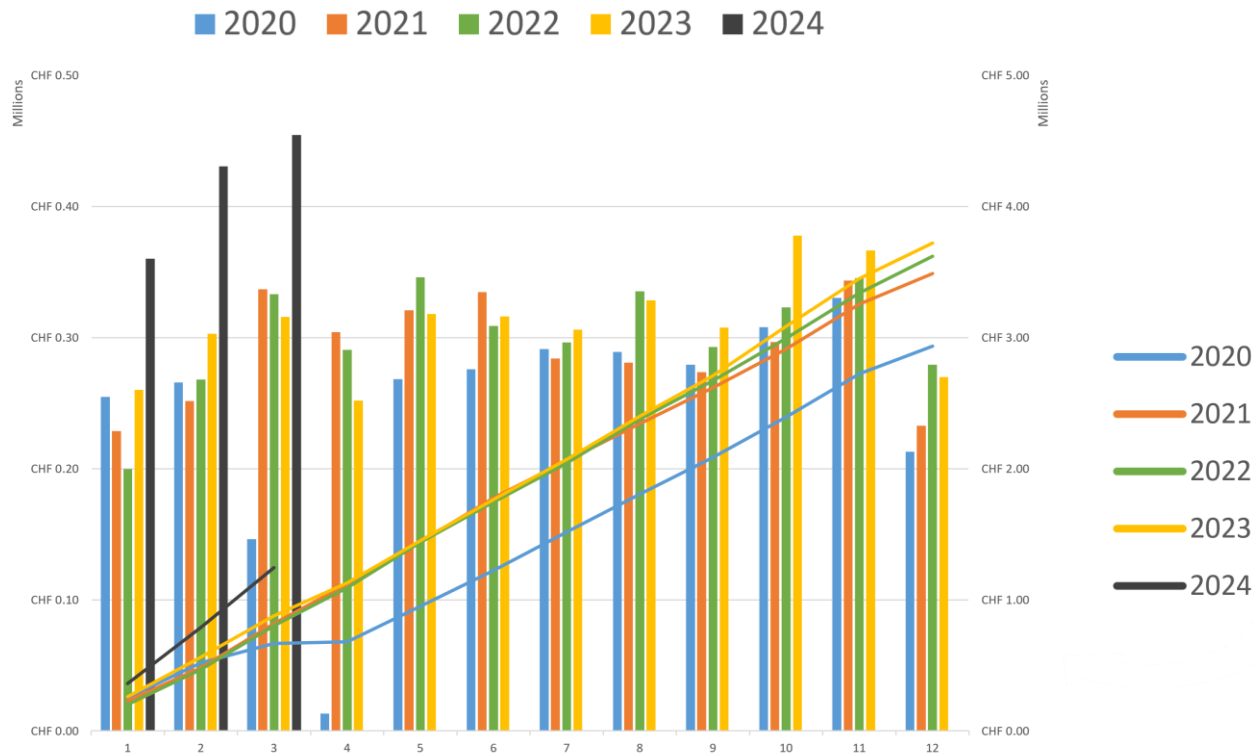
- External academic users (4% of our revenues)

Invoicing to companies

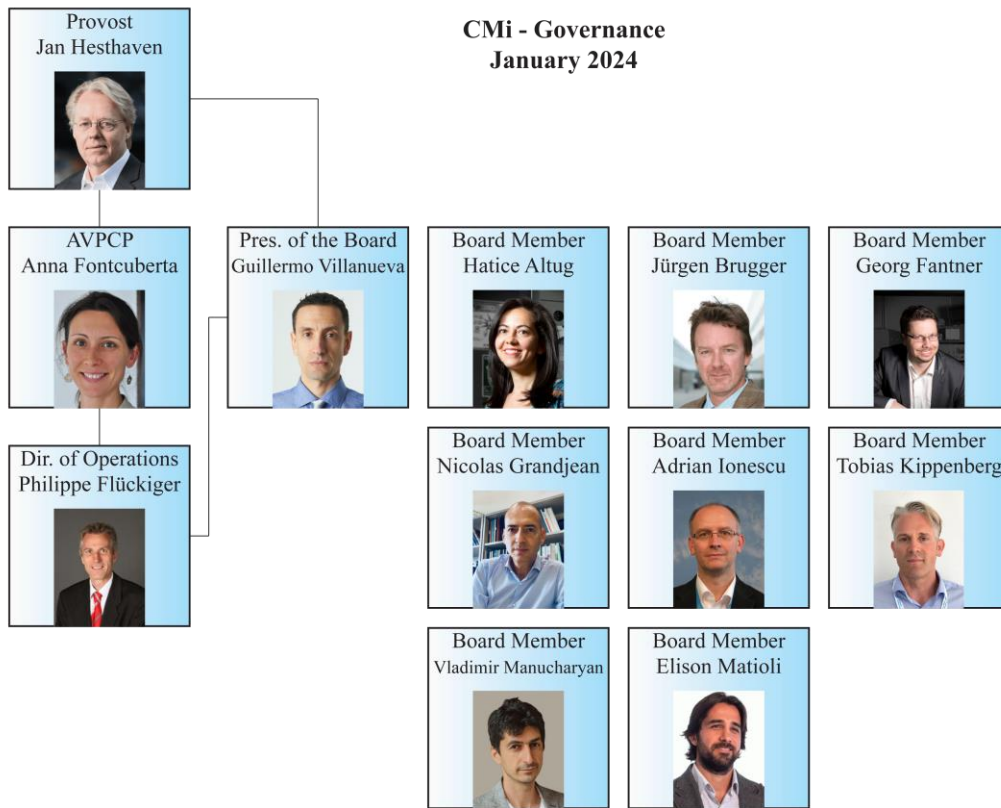


- Industrial users (43% of our revenues)

Total invoicing to all users



- In total, the invoicing to all users for Q1 2024 shows a progression of 42%.

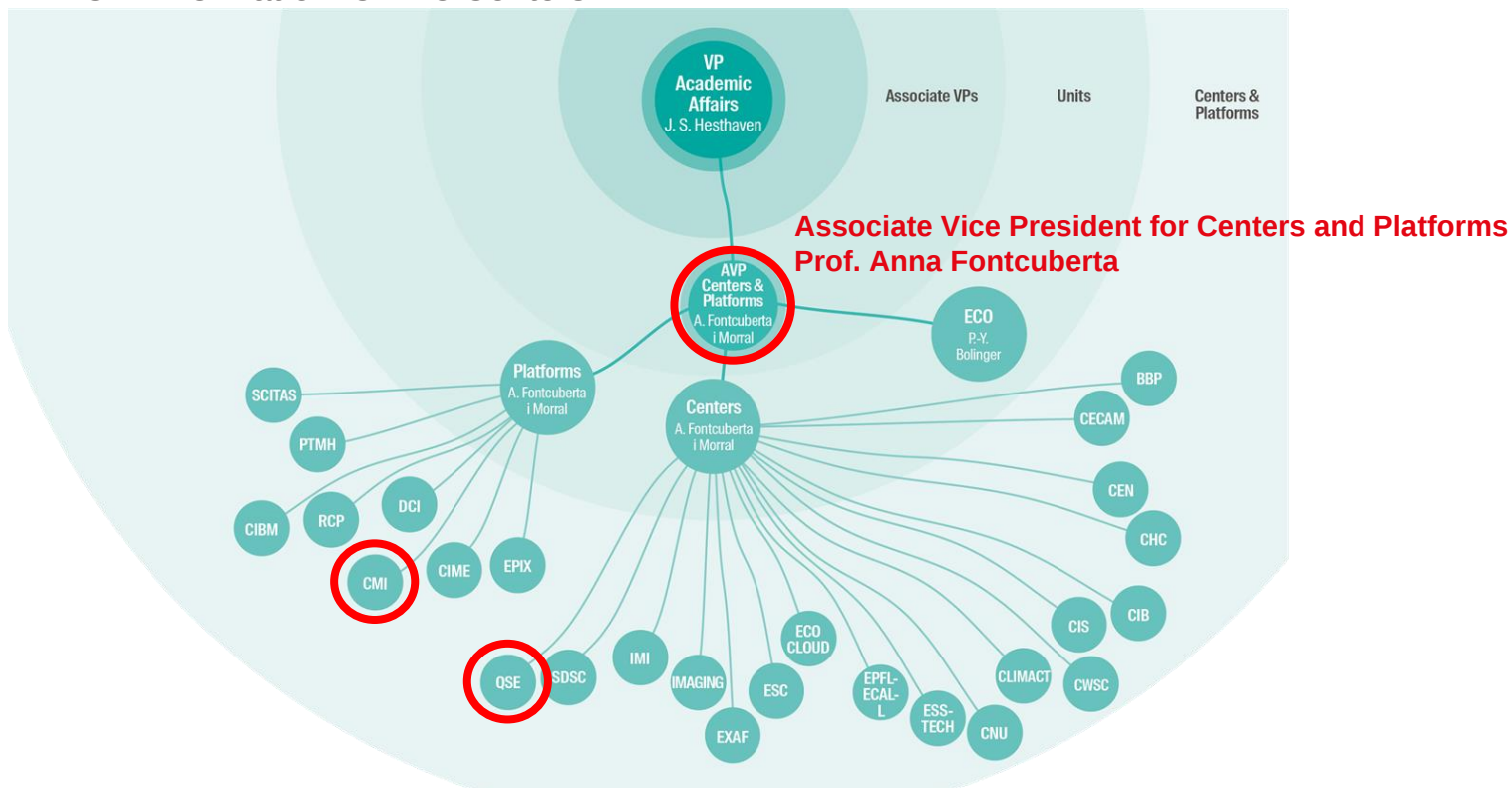


Governance

- The CMi reports to our Associate Vice President for Centers and Platforms
- Our executive board is composed of 9 Professors including our president
- Members nominated for a period of 4 years from
01.11.2018 until 31.10.2022
01.11.2022 until 31.10.2026

- CMi reports to our Associate VP for Centers and Platforms : Prof. A. Fontcuberta
- President of our board : Prof. G. Villanueva

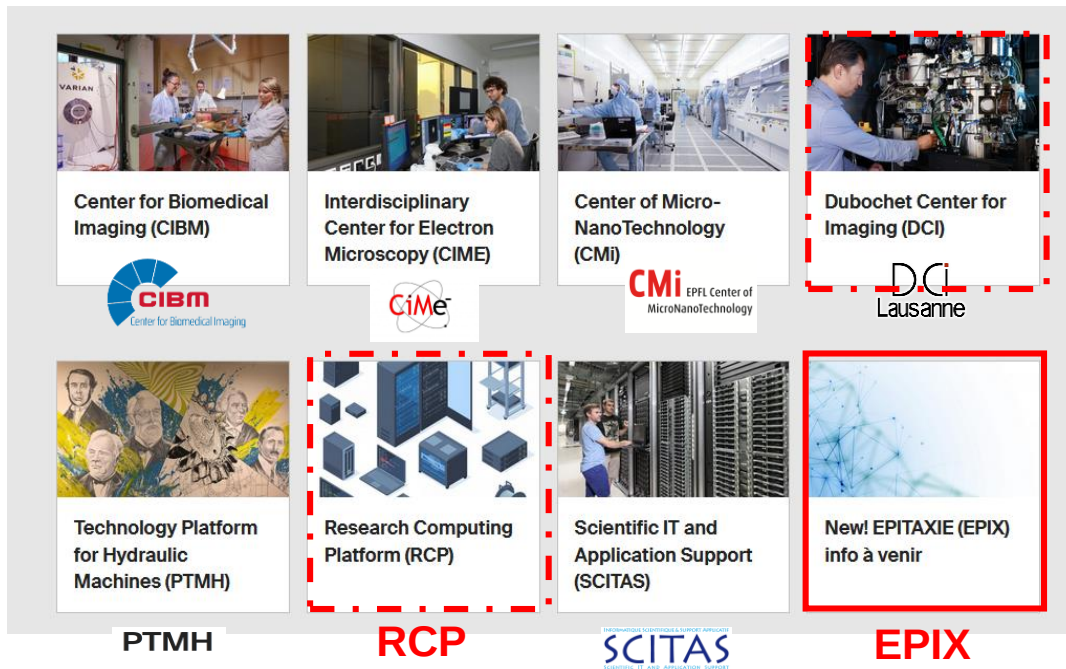
AVP-CP : 8 Platforms + 18 Centers



- The CMi is one of the 8 platforms reporting to our AVP-CP
- 18 Centers are also reporting to our AVP-CP including the C. for Quantum S&E



<https://www.epfl.ch/research/facilities/>



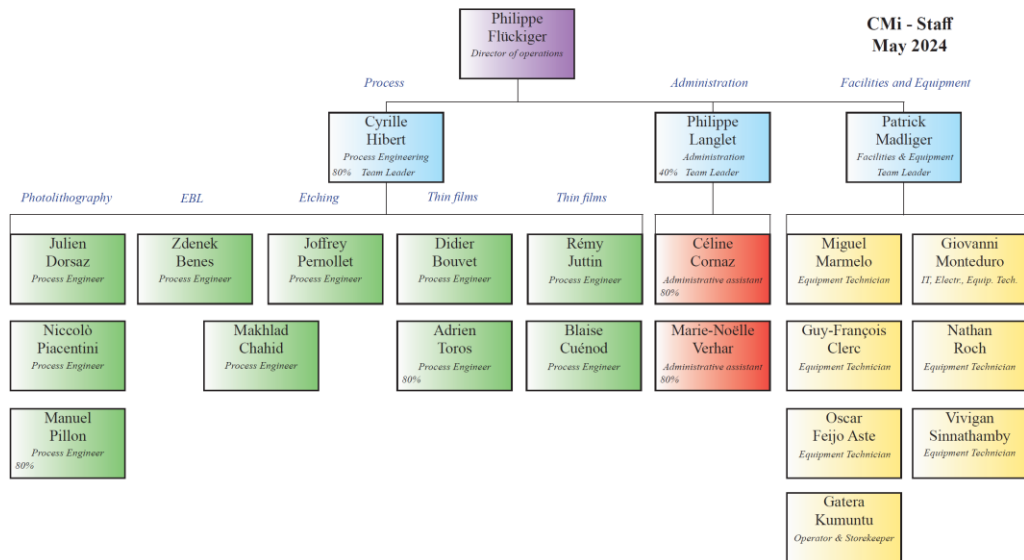
- CMi collaborates with other platforms like CIME and EPIX.
- CIME : Center for Electron Microscopy
- EPIX : Epitaxy platform

- All EPFL platforms in one brochure
- An overview of the excellent infrastructure & outstanding staff
- For existing and new researchers



<https://www.epfl.ch/research/facilities/>

- We have now a brochure describing all the platforms and all the centers at EPFL.

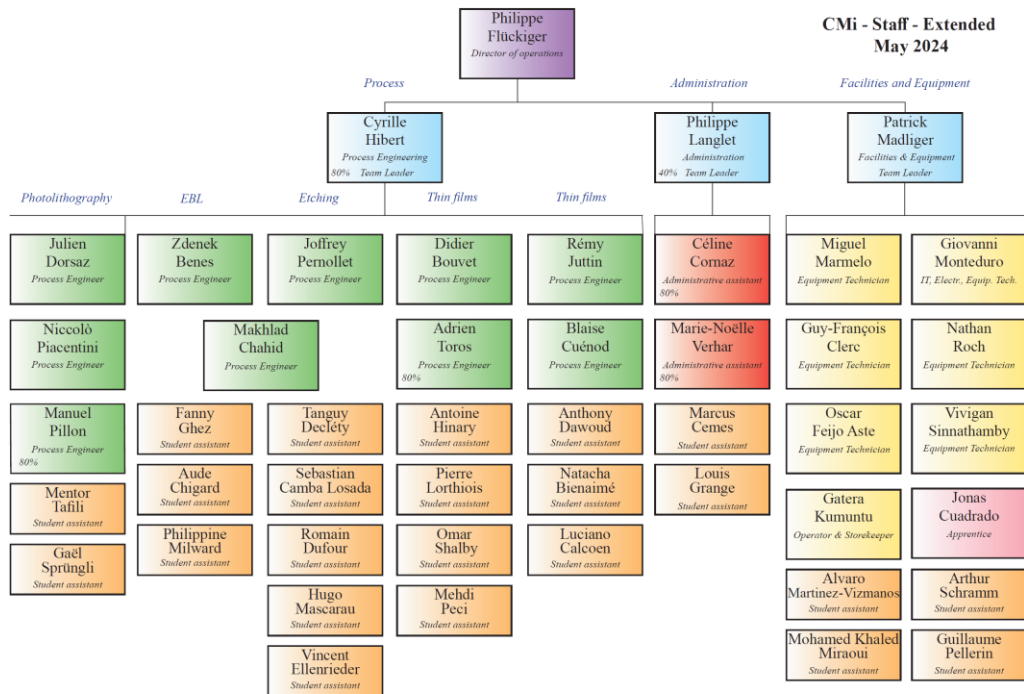


Staff

- Staff composed of 21.4 FTE employees
- We have plans to increase to 23.4 FTE employees by 2025 with 2 equipment engineers
- 3 employees are currently still under non-permanent positions
- Employ 14 student assistants (part time)



- Our staff is specialized in Process / Administration / Facilities and Equipment
- Our staff has very few members



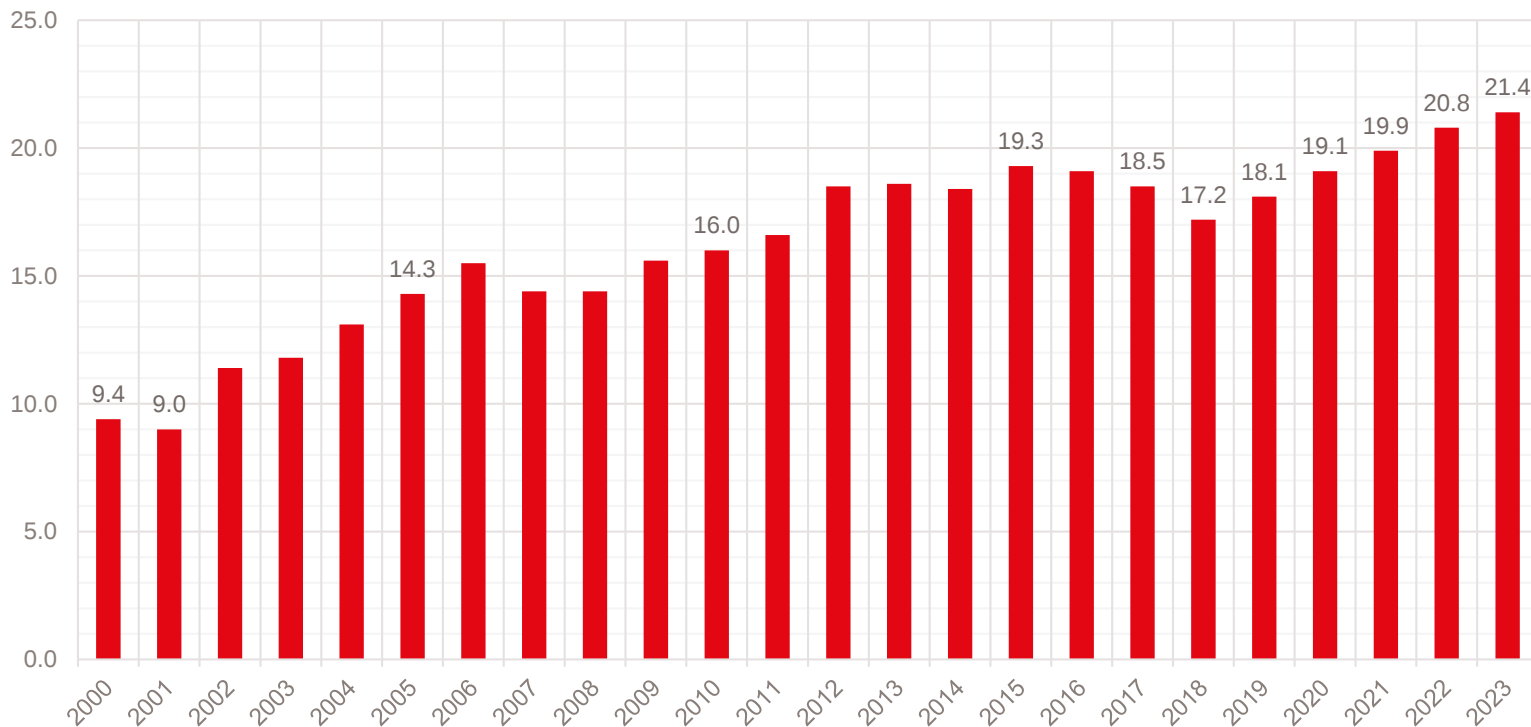
Staff

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- We have plans to increase to 23.4 FTE employees by 2025 with 2 equipment engineers
- 3 employees are currently still under non-permanent positions
- Employ 14 student assistants (part time)



- The 14 student assistants play an important role in the daily operations
- They provide services and they perform training for the new users

EPFL-CMi : Average FTE



- Evolution of the number of FTE since the creation of the CMi.

16 tools in the process to be installed

Delivery

1	2022 PVD Cluster Alliance Concept CT-200
2	2023 Dielectric etcher KLA SPTS Omega Synapse
3	2024 EBL2 Raith EBPG5200 Plus
4	2024 EBL1 Raith Upgrade of EBPG5000 Plus
5	2024 Thermal Evaporator Alliance Concept EVA 451
6	2024 Lift-off Evaporator Bühler SYRUSpro 700 LT
7	2024 Coater Developer EVG150
8	2024 ALD for SC nitrides NbN NbTiN Oxford FlexAl
9	2025 HV Sputter Nb Plassys MP500S-UHV
10	2025 UHV evaporator Al Plassys MEB550S
11	2024 Flip-Chip Bonder SET ACCuRA OPTO
12	2024 RIE Etcher Oxford PlasmaPro 80 RIE
13	2024 ALD AL2O3 HFO2 SiO2 Beneq R2
14	2025 ALD VO2
15	2024 Dicing Saw DAD3221
16	2025 Lift-off wet benches



Dry etching of dielectrics

- KLA SPTS Synapse
- O₂, SF₆, Ar, N₂, C₄F₈, He, CHF₃ and H₂ or CH₄

Plasma Etching

SPTS Rapier DSE, dry etcher, fluorine chemistry

Alcatel AMS 200 SE, dry etcher, fluorine chemistry

SPTS APS Dielectric Etcher, dry etcher, fluorine chemistry

TEL Unity Me, dry etcher, fluorine chemistry

STS Multiplex ICP, dry etcher, chlorine and bromine chemistry

Oxford PlasmaPro100 Cobra, dry etcher, chlorine and bromine chemistry

- Zone 2

- Delivered on 6 December 2023. To be accepted in May 2024.
- To separate metal free dielectric etching and to offer more capacity.

Delivery

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2	2023 Dielectric etcher KLA SPTS Omega Synapse
3	2024 EBL2 Raith EBPG5200 Plus
4	2024 EBL1 Raith Upgrade of EBPG5000 Plus
5	2024 Thermal Evaporator Alliance Concept EVA 451
6	2024 Lift-off Evaporator Bühler SYRUSpro 700 LT
7	2024 Coater Developer EVG150
8	2024 ALD for SC nitrides NbN NbTiN Oxford FlexAl
9	2025 HV Sputter Nb Plassys MP500S-UHV
10	2025 UHV evaporator AI Plassys MEB550S
11	2024 Flip-Chip Bonder SET ACCuRA OPTO
12	2024 RIE Etcher Oxford PlasmaPro 80 RIE
13	2024 ALD AL2O3 HFO2 SiO2 Beneq R2
14	2025 ALD VO2
15	2024 Dicing Saw DAD3221
16	2025 Lift-off wet benches



Electron beam lithography system

Raith EBPG5000+, electron beam lithography system

Electron beam lithography

- Second EBL tool is purchased
 - Delivery in August 2024
 - Raith EBPG5200 Plus
 - advanced fracturing modes for lowest line-edge roughness
 - 10-holder airlock
 - with full 200-mm writing capability
 - 200MHz when available
 - + upgrade of EBL1, pattern generator 125MHz, 20 bit upgrade
- Purchased on 28 November 2022.
 - To be delivered in August 2024.
- Zone 1

Delivery

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2	2023 Dielectric etcher KLA SPTS Omega Synapse
3	2024 EBL2 Raith EBPG5200 Plus
4	2024 EBL1 Raith Upgrade of EBPG5000 PLUS
5	2024 Thermal Evaporator Alliance Concept EVA 451
6	2024 Lift-off Evaporator Bühler SYRUSpro 700 LT
7	2024 Coater Developer EVG150
8	2024 ALD for SC nitrides NbN NbTiN Oxford FlexAI
9	2025 HV Sputter Nb Plassys MP500S-UHV
10	2025 UHV evaporator Al Plassys MEB550S
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12	2024 RIE Etcher Oxford PlasmaPro 80 RIE
13	2024 ALD AL2O3 HFO2 SiO2 Beneq R2
14	2025 ALD VO2
15	2024 Dicing Saw DAD3221
16	2025 Lift-off wet benches



PVD Thermal Evaporator

- Alliance Concept EVA 451
- with load lock
- 4 sources
- cryogenic pump

- Zone 11

Evaporation

Alliance-Concept EVA 760, evaporator, e-gun

Leybold Optics LAB 600H, evaporator, e-gun, IAD

Bühler Alzenau LTE - Long Throw Evaporator

Vacotec, evaporator, thermal sources

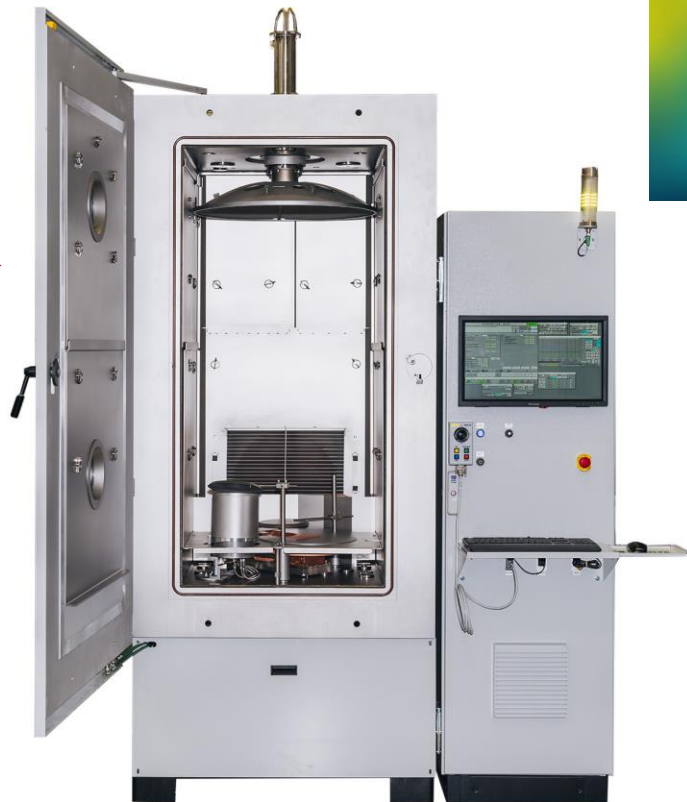
Vacotec VACO 250, evaporator, thermal sources

Plassys MEB550SL3, UHV evaporator, Josephson junctions

- Purchased on 20 February 2023. To be delivered in July 2024.
- Appropriate to deposit conductive layers for eliminating charges during EBL

Delivery

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PVD Lift-off evaporator

- Bühler Leybold Optics
- LTE 700
- Long Throw Evacuation
- source to substrate distance is 1330mm
- RF 80 ion source

- EVA 760 : 450 350 250 mm
- LAB 600H : 1010 630 mm

- Zone 6

Evaporation

Alliance-Concept EVA 760, evaporator, e-gun

Leybold Optics LAB 600H, evaporator, e-gun, IAD

Bühler Alzenau LTE - Long Throw Evaporator

Vacotec, evaporator, thermal sources

Vacotec VACO 250, evaporator, thermal sources

Plassys MEB550SL3, UHV evaporator, Josephson junctions

- Purchased on 9 March 2023.
- To be delivered in June 2024.

Delivery

1	2022 PVD Cluster Alliance Concept CT-200
2	2023 Dielectric etcher KLA SPTS Omega Synapse
3	2024 EBL2 Raith EBPG5200 Plus
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6	2024 Lift-off Evaporator Bühler SYRUSpro 700 LT
7	2024 Coater Developer EVG150
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10	2025 UHV evaporator AI Plassys MEB550S
11	2024 Flip-Chip Bonder SET ACCuRA OPTO
12	2024 RIE Etcher Oxford PlasmaPro 80 RIE
13	2024 ALD AL2O3 HFO2 SiO2 Beneq R2
14	2025 ALD VO2
15	2024 Dicing Saw DAD3221
16	2025 Lift-off wet benches



Automatic coaters & developers

Süss MicroTec ACS200 Gen3, cluster for i-line photoresists

EVG 150, cluster for i-line photoresists

Hamatech HMR900, mask (Cr-blanks) processing equipment

Tokyo Electron Cleantrack ACT 8, track for DUV photoresists

Coater Developer

- EVG 150
- Tooled for 100mm and 150mm
- 3 coating modules
- 4 low viscosity lines
- 4 medium/high viscosity lines
- 4 lift-off underlayer lines
- 8 hotplates
- 3 chill plates
- 1 HMDS
- 1 developer station with 3 lines

- Purchased on 9 March 2023.
- To be delivered in August 2024.

Delivery

1	2022 PVD Cluster Alliance Concept CT-200
2	2023 Dielectric etcher KLA SPTS Omega Synapse
3	2024 EBL2 Raith EBPG5200 Plus
4	2024 EBL1 Raith Upgrade of EBPG5000 PLUS
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13	2024 ALD AL2O3 HfO2 SiO2 Beneq R2
14	2025 ALD VO2
15	2024 Dicing Saw DAD3221
16	2025 Lift-off wet benches



Atomic Layer Deposition

- Oxford FlexAl ALD
- Superconducting NbN and TiN
- 6 precursor (plus H₂O)

- Zone 18

Atomic Layer Deposition BENEQ TFS200 (ALD I)

Atomic Layer Deposition BENEQ TFS200 (ALDII)

- Purchased on 22 December 2023.
- To be delivered in October 2024.

Delivery

1	2022 PVD Cluster Alliance Concept CT-200
2	2023 Dielectric etcher KLA SPTS Omega Synapse
3	2024 EBL2 Raith EBPG5200 Plus
4	2024 EBL1 Raith Upgrade of EBPG5000 PLUS
5	2024 Thermal Evaporator Alliance Concept EVA 451
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16	2025 Lift-off wet benches



Evaporation

Alliance-Concept EVA 760, evaporator, e-gun

Leybold Optics LAB 600H, evaporator, e-gun, IAD

Bühler Alzenau LTE - Long Throw Evaporator

Vacotec, evaporator, thermal sources

Vacotec VACO 250, evaporator, thermal sources

Plassys MEB550SL3, UHV evaporator, Josephson junctions

HV Evaporator for JJ

- Plassys MEB550S HV
- Single chamber system
- Superconductors evaporation
- Josephson Junctions fabrication

- Zone 20

- Purchased on 11 April 2024.
- To be delivered in Q2 2025.

Delivery

1	2022 PVD Cluster Alliance Concept CT-200
2	2023 Dielectric etcher KLA SPTS Omega Synapse
3	2024 EBL2 Raith EBPG5200 Plus
4	2024 EBL1 Raith Upgrade of EBPG5000 PLUS
5	2024 Thermal Evaporator Alliance Concept EVA 451
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14	2025 ALD VO2
15	2024 Dicing Saw DAD3221
16	2025 Lift-off wet benches



UHV sputter

- Plassys MP500S UHV
- Nb/Al-AlOx/Nb
- Josephson Junctions fabrication

Sputtering

Pfeiffer SPIDER 600, sputter, cluster system

Alliance-Concept CT200, sputter, cluster system

Alliance-Concept DP 650, Sputter single chamber multi-target

- Purchased on 2 January 2024.
- To be delivered in Q2 2025.

- Zone 20

Delivery

1	2022 PVD Cluster Alliance Concept CT-200
2	2023 Dielectric etcher KLA SPTS Omega Synapse
3	2024 EBL2 Raith EBPG5200 Plus
4	2024 EBL1 Raith Upgrade of EBPG5000 Plus
5	2024 Thermal Evaporator Alliance Concept EVA 451
6	2024 Lift-off Evaporator Bühler SYRUSpro 700 LT
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8	2024 ALD for SC nitrides NbN NbTiN Oxford FlexAl
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10	2025 UHV evaporator AI Plassys MEB550S
11	2024 Flip-Chip Bonder SET ACC μ RA OPTO
12	2024 RIE Etcher Oxford PlasmaPro 80 RIE
13	2024 ALD AL ₂ O ₃ HFO ₂ SiO ₂ Beneq R2
14	2025 ALD VO ₂
15	2024 Dicing Saw DAD3221
16	2025 Lift-off wet benches



Chip to wafer bonder

- SET ACC μ RA OPTO
 - Flip-Chip Bonder
 - Die Bonder
 - Pick and place
 - 0.5um accuracy
 - Thermocompression
 - Reflow
 - UV curing
 - Gold, Gold/Tin, Indium, Copper
-
- Zone 6

Die Bonding

Finetech FINEPLACER lambda, Die Bonder

- Purchased on 14 March 2024.
- To be delivered in September 2024

Delivery

1	2022 PVD Cluster Alliance Concept CT-200
2	2023 Dielectric etcher KLA SPTS Omega Synapse
3	2024 EBL2 Raith EBPG5200 Plus
4	2024 EBL1 Raith Upgrade of EBPG5000 PLUS
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14	2025 ALD VO2
15	2024 Dicing Saw DAD3221
16	2025 Lift-off wet benches



RIE Etcher

- Oxford PlasmaPro RIE 80
- Parallel plate reactor
- Fluorine chemistry
- Graphite, SiGe, hBN

- Zone 3

Plasma Etching

SPTS Rapier DSE, dry etcher, fluorine chemistry

Alcatel AMS 200 SE, dry etcher, fluorine chemistry

SPTS APS Dielectric Etcher, dry etcher, fluorine chemistry

TEL Unity Me, dry etcher, fluorine chemistry

STS Multiplex ICP, dry etcher, chlorine and bromine chemistry

Oxford PlasmaPro100 Cobra, dry etcher, chlorine and bromine chemistry

- Purchased on 5 December 2023.
- To be delivered in September 2024.

Delivery

1	2022 PVD Cluster Alliance Concept CT-200
2	2023 Dielectric etcher KLA SPTS Omega Synapse
3	2024 EBL2 Raith EBPG5200 Plus
4	2024 EBL1 Raith Upgrade of EBPG5000 PLUS
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14	2025 ALD VO ₂
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16	2025 Lift-off wet benches



Atomic Layer Deposition BENEQ TFS200 (ALD I)

Atomic Layer Deposition BENEQ TFS200 (ALDII)

Atomic Layer Deposition

- Beneq R2
- Al₂O₃ HfO₂ SiO₂
- HfO₂ @ 90°C
- Allowed on Au coated wafers

- Zone 4

- Purchased on 2 May 2024.
- To be delivered in Q4 2024.

Delivery

1	2022 PVD Cluster Alliance Concept CT-200
2	2023 Dielectric etcher KLA SPTS Omega Synapse
3	2024 EBL2 Raith EBPG5200 Plus
4	2024 EBL1 Raith Upgrade of EBPG5000 PLus
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14	2025 ALD VO2
15	2024 Dicing Saw DAD3221
16	2025 Lift-off wet benches



Dicing – Cutting

Disco DAD321, automatic dicing saw



Dicing Saw

- Disco DAD3221
- Semi automatic dicing saw
- Circle cut for edge trimming

- Zone 22

- Purchased on 9 April 2024.
- To be delivered in Q4 2024.

Delivery

1	2022 PVD Cluster Alliance Concept CT-200
2	2023 Dielectric etcher KLA SPTS Omega Synapse
3	2024 EBL2 Raith EBPG5200 Plus
4	2024 EBL1 Raith Upgrade of EBPG5000 Plus
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14	2025 ALD VO2
15	2024 Dicing Saw DAD3221
16	2025 Lift-off wet benches



Lift-off Wet Benches

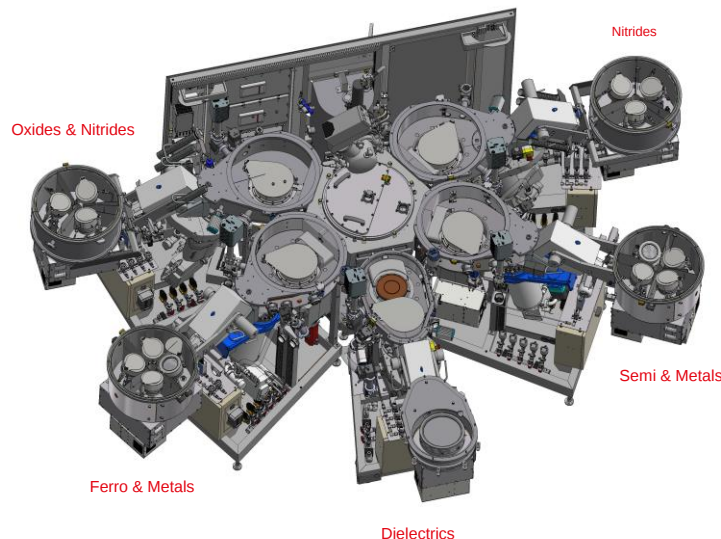
- With recirculation and filtering

- Zone 1

- Call for tender to be published in March 2024
- To be delivered in Q2 2025

Delivery

1	2022 PVD Cluster Alliance Concept CT-200
2	2023 Dielectric etcher KLA SPTS Omega Synapse
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14	2025 ALD VO2
15	2024 Dicing Saw DAD3221
16	2025 Lift-off wet benches



PVD Cluster Tool

- Alliance Concept CT-200
- 5 chambers
- Oxides & nitrides (3x100mm)
- Ferro & metals (4x100mm)
- Dielectrics (1x250mm)
- Nitrides (3x100mm)
- Semi & metals (4x100mm)
- Zone 4

Sputtering

Pfeiffer SPIDER 600, sputter, cluster system

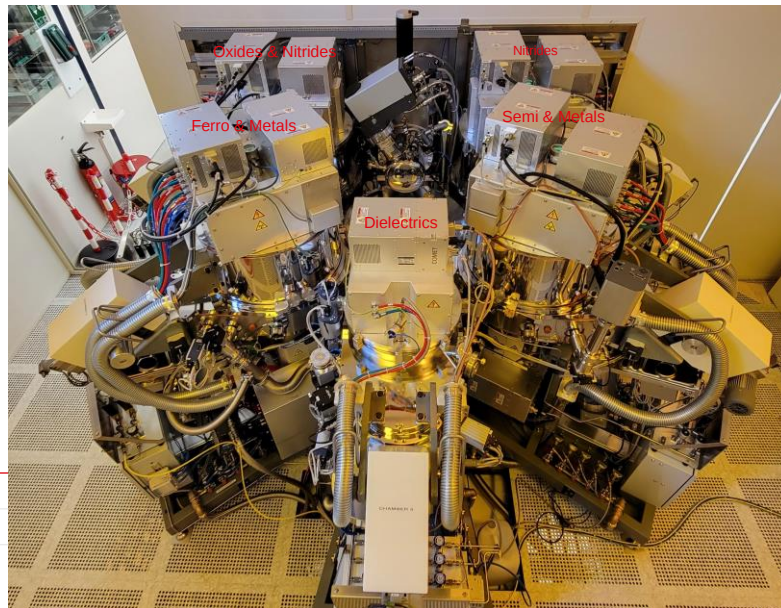
Alliance-Concept CT200, sputter, cluster system

Alliance-Concept DP 650, Sputter single chamber multi-target

- A new PVD Cluster Tool with 5 chambers delivered on 23 September 2022
- The acceptance of the tool is scheduled for this summer.

Delivery

1	2022 PVD Cluster Alliance Concept CT-200
2	2023 Dielectric etcher KLA SPTS Omega Synapse
3	2024 EBL2 Raith EBPG5200 Plus
4	2024 EBL1 Raith Upgrade of EBPG5000 PLUS
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PVD Cluster Tool

- Alliance Concept CT-200
- 5 chambers
- Oxides & nitrides (3x100mm)
- Ferro & metals (4x100mm)
- Dielectrics (1x250mm)
- Nitrides (3x100mm)
- Semi & metals (4x100mm)
- Zone 4

Sputtering

Pfeiffer SPIDER 600, sputter, cluster system

Alliance-Concept CT200, sputter, cluster system

Alliance-Concept DP 650, Sputter single chamber multi-target

- A new PVD Cluster Tool with 5 chambers is currently under acceptance tests

Delivery

1	2022 PVD Cluster Alliance Concept CT-200
2	2023 Dielectric etcher KLA SPTS Omega Synapse
3	2024 EBL2 Raith EBPG5200 Plus
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16	2025 Lift-off wet benches

In discussion for 2025 

1° RIE for NbN NbTiN TaN TiN

- Exclusively for superconductors
- Fluorine chemistry
- High purity

2° ALD for microelectronic clean oxides

- high-k doped (Zr and Si doped HfO₂) ferroelectrics
- VO₂

3° Defect inspection metrology

- Particule counting
- Defect classification

4° Optical overlay and CD metrology

- Pattern to pattern alignment
- Measurements of the dimensions of the fine patterns

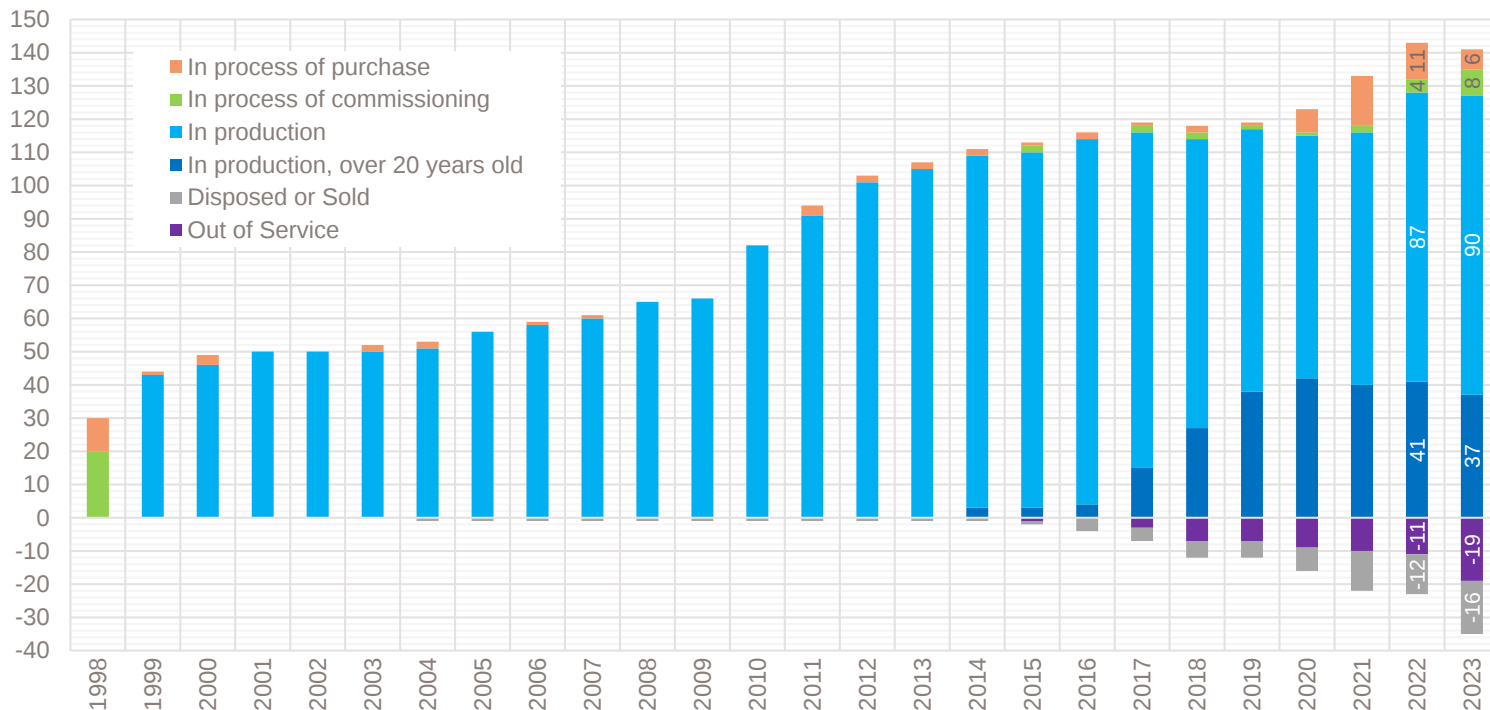
5° Dense component packaging

- Chip to chip bonding
- Fiber to chip bonding
- Testing

6° 2D transfer system

- Transfer and alignment of 1D nanowires and 2D crystal flakes
- Fabrication of heterostructures and twisted layered structures

EPFL-CMi : Number of machines



- 127 machines in production (31/12/2023)
- 14 machines in process of commissioning or purchase (31/12/2023)



- The value of the equipment reaches 43.8 MCHF (purchase price)
- 3.5 MCHF were invested in 2023

Historical Milestones

Microelectronics & MEMS

1998

- CMi created in 1998 & Cleanroom opened in March 1999
- Basic Microelectronics processes
- MEMS processes like **Deep silicon etching, SU-8**

Nano / Electron Beam Lithography

2005

- **Electron Beam Lithography** ordered in december in 2005
- Focused Ion Beam ordered in september 2003
- Atomic Layer Deposition in 2011

Cleanroom extension 24/7

2010

- Cleanroom extension opened in 2010 for **more flexibility** and cheaper access
- **Operated now in 24/7 mode** since 2012
- **PDMS, SU-8, Chemistry, Metrology, Non-conventional processes**

Materials Diversity

2013

- **Ion Beam Etching**, PVD, ALD, PLD, Dry Etching
- Chemistry
- Photolithography: Mask Fabrication, Coater & Developer, Mask Aligner

DUV Stepper lithography

2019

- **DUV stepper**
- Renewal of aging tools & Adding new capabilities
- Envision the acquisition of a second EBEAM at the horizon of 2022

Renewal & Broadening

2019

- Deep Si etcher - XeF2 etcher - CMP - Post CMP Cleaner - Super Critical Dryer - Metal etcher
- **PVD Cluster** - LPCVD furnaces - PECVD - Flash Lamp Annealing - Direct Writer
- **Wafer bonding** - CVD diamond - Optical Profiler - SEM - Ellipsometer

Quantum Science & Engineering

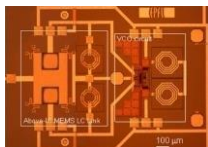
2022

- UHV evaporator (2x) for **Josephson Junctions** - UHV sputter for **Josephson Junctions** - ALD for SC
- Second electron beam lithography system
- **Cleanroom extension in 2025**

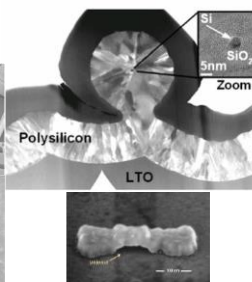
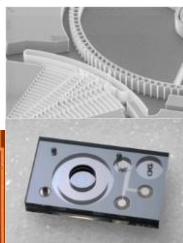
Historical Milestones



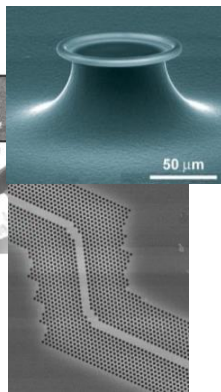
IC



MEMS



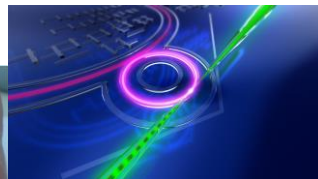
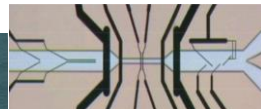
Nano



Bio & Mat.

Quantum

Quantum



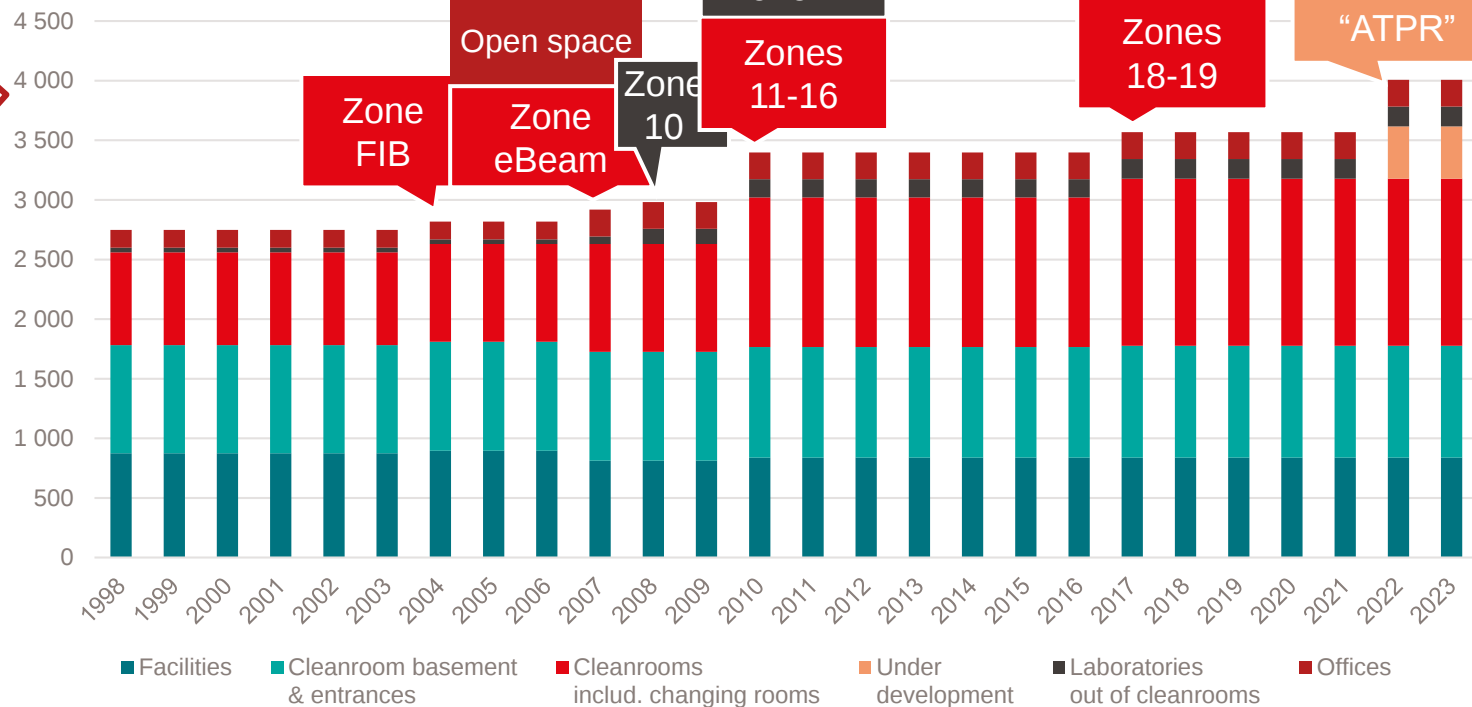
- Broadening the CMi offer and the CMi users base along the time



Initial surface BM-1 (1998)	900m ²
Extension BM+1 (2010)	350m ²
Extension BM0 (2017)	150m ²
Extension BM0 (2025)	440m ²
Total Surface	1840m²

- Space is a concern
- 2025: Transform the space received from the STI at level BM0 into a cleanroom

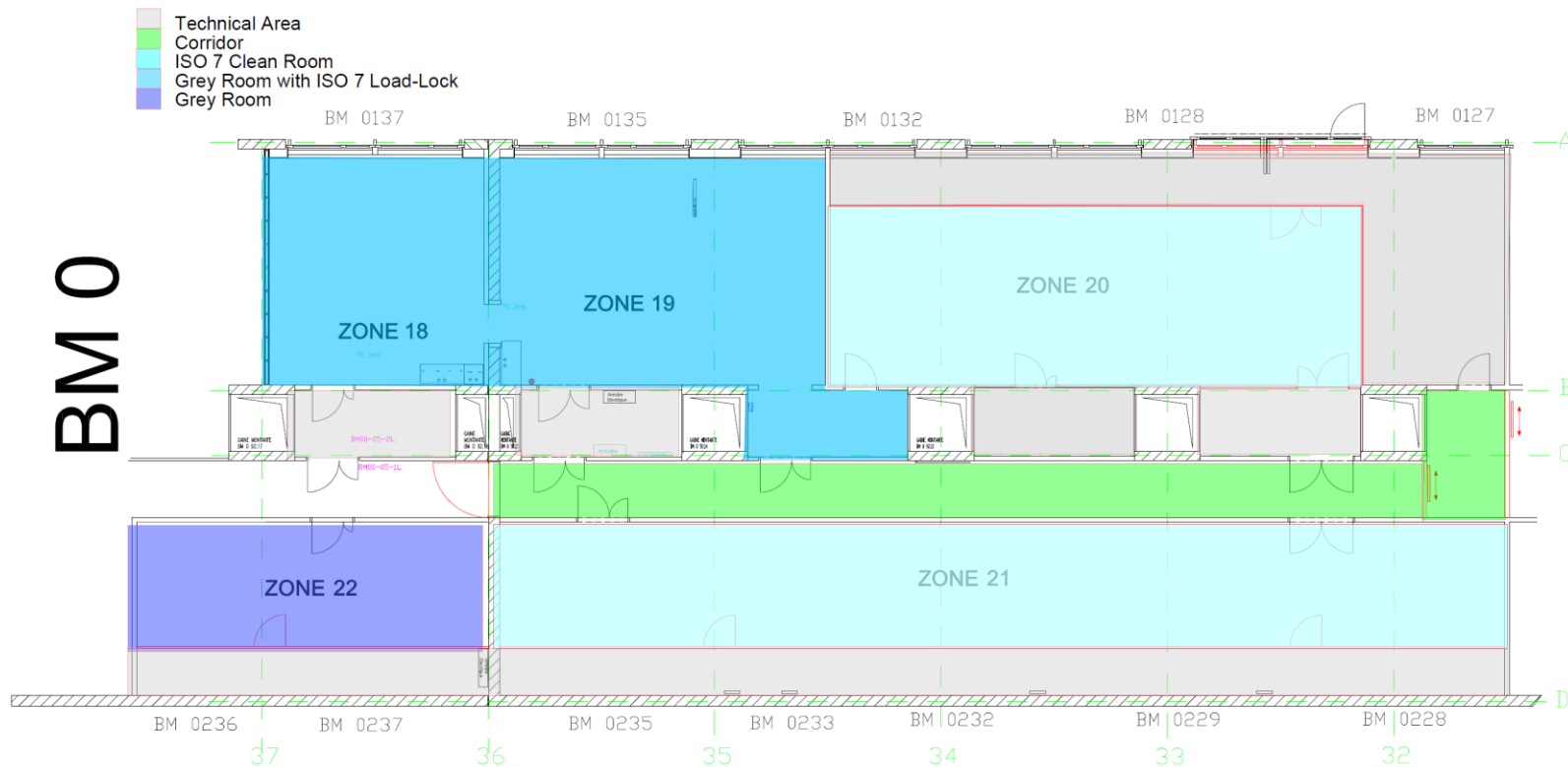
EPFL-CMi : Square meters



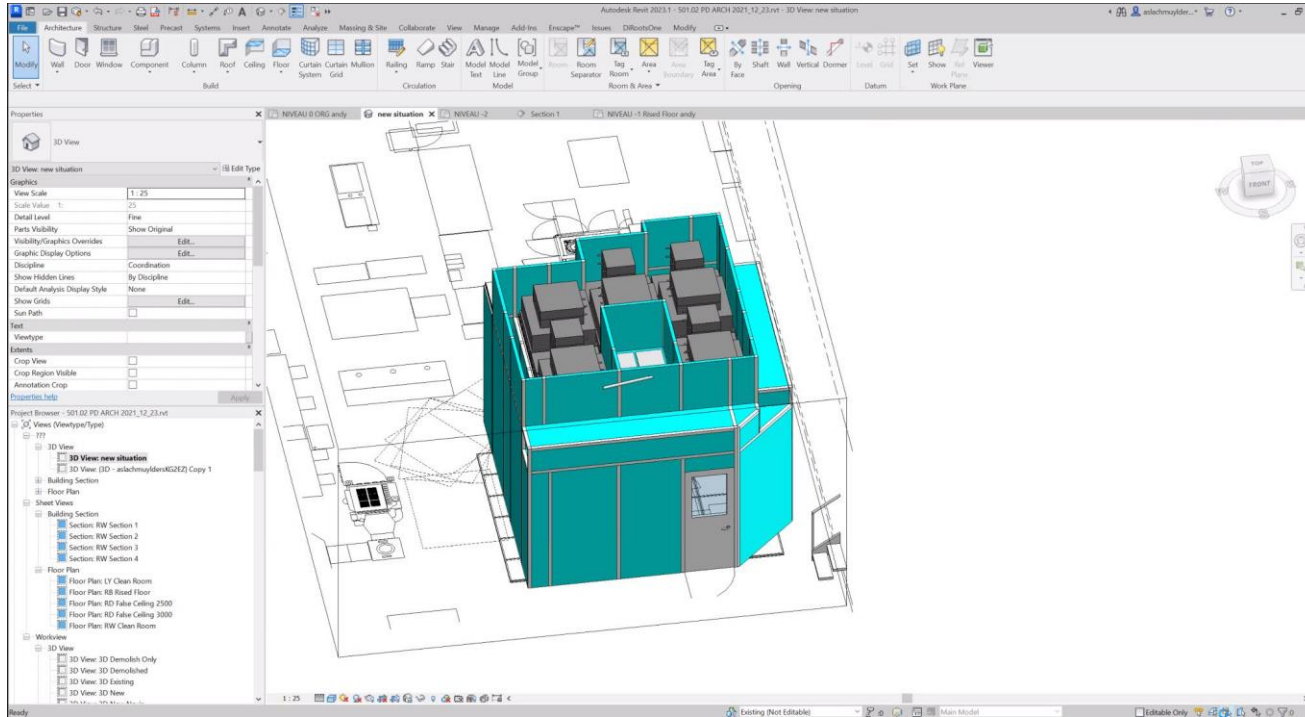
- 1'400 m² of CR + 440 m² under development + 165 m² of standard labs
- 1'780 m² of facilities, basement & entrances + 225 m² of offices



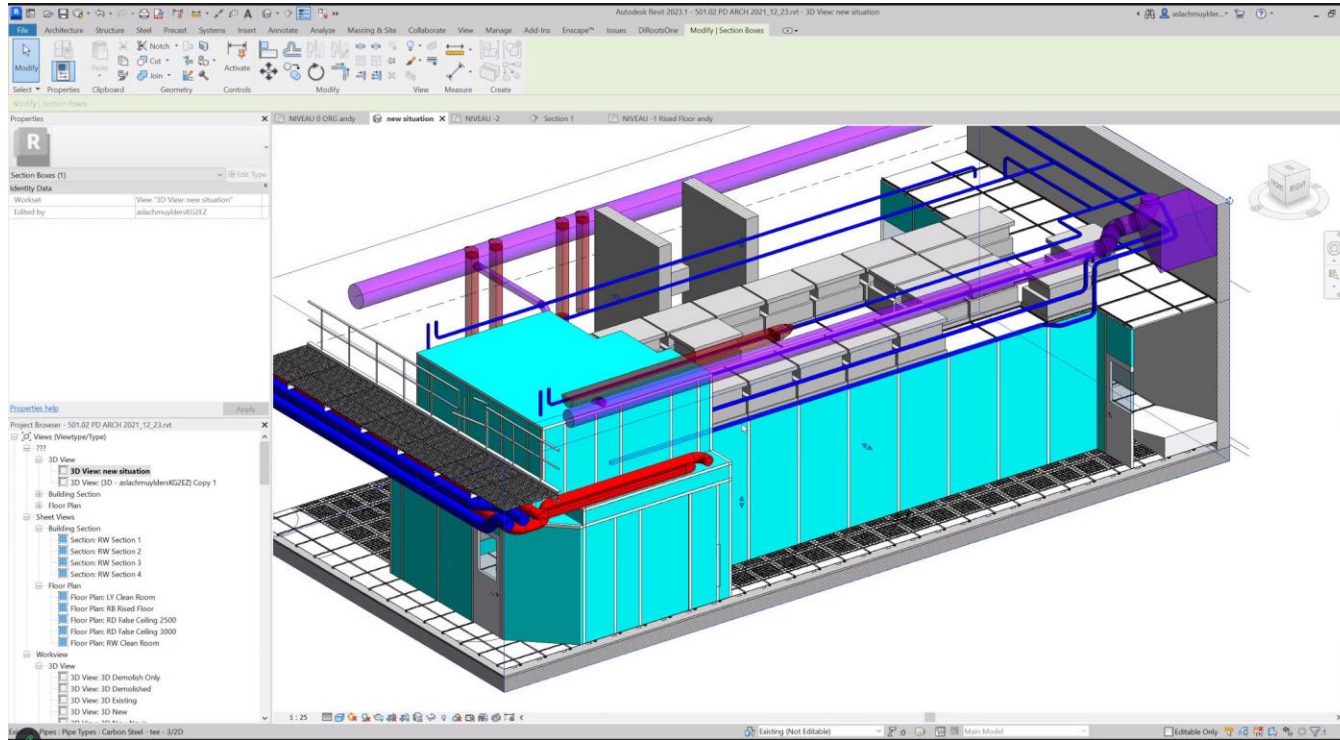
- Transform this 700m² space into a cleanroom space
- Preuve du besoin approved by the CEPF on 24.04.2024



- We will build cleanrooms accessible by a central clean corridor
- 365m² of cleanroom extension (and grey area) will be available in 2025



- We will transform the extremity of zone 1 to accommodate EBL2
- We need tight control of temperature, EM noise and the acoustic noise



- A view of the future zone 1 with EBL2 at the extremity

- Processing Equipment

Scientific Equipment Levels -1 / 0 / +1	50 MCHF
Total	50 MCHF

- Cleanroom Infrastructures

Cleanroom Infrastructures Level -1	12 MCHF
Cleanroom Infrastructures Level +1	7 MCHF
Cleanroom Infrastructures Level 0 (1)	2 MCHF (2017)
Cleanroom Infrastructures Level 0 (2)	4 MCHF (2025)
Total	25 MCHF

- Total 75MCHF

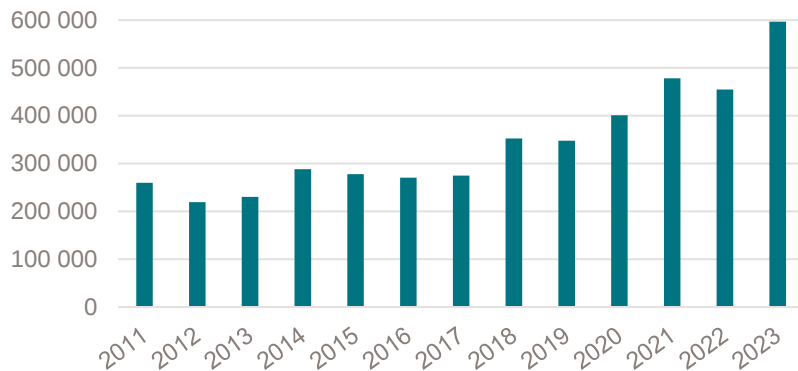
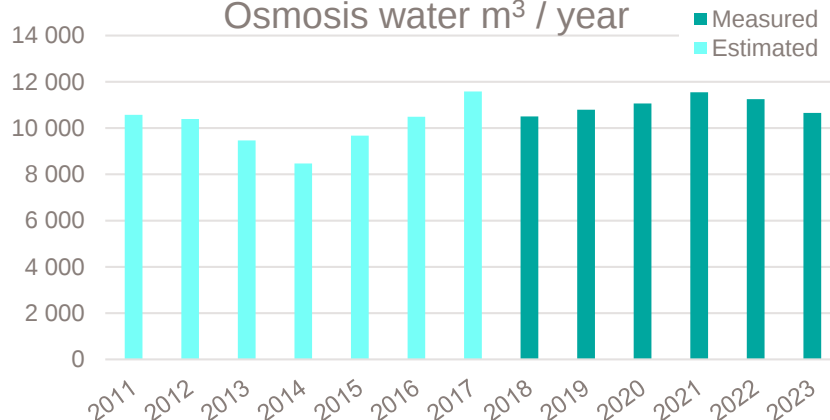


EPFL-Ecublens
43 GWh

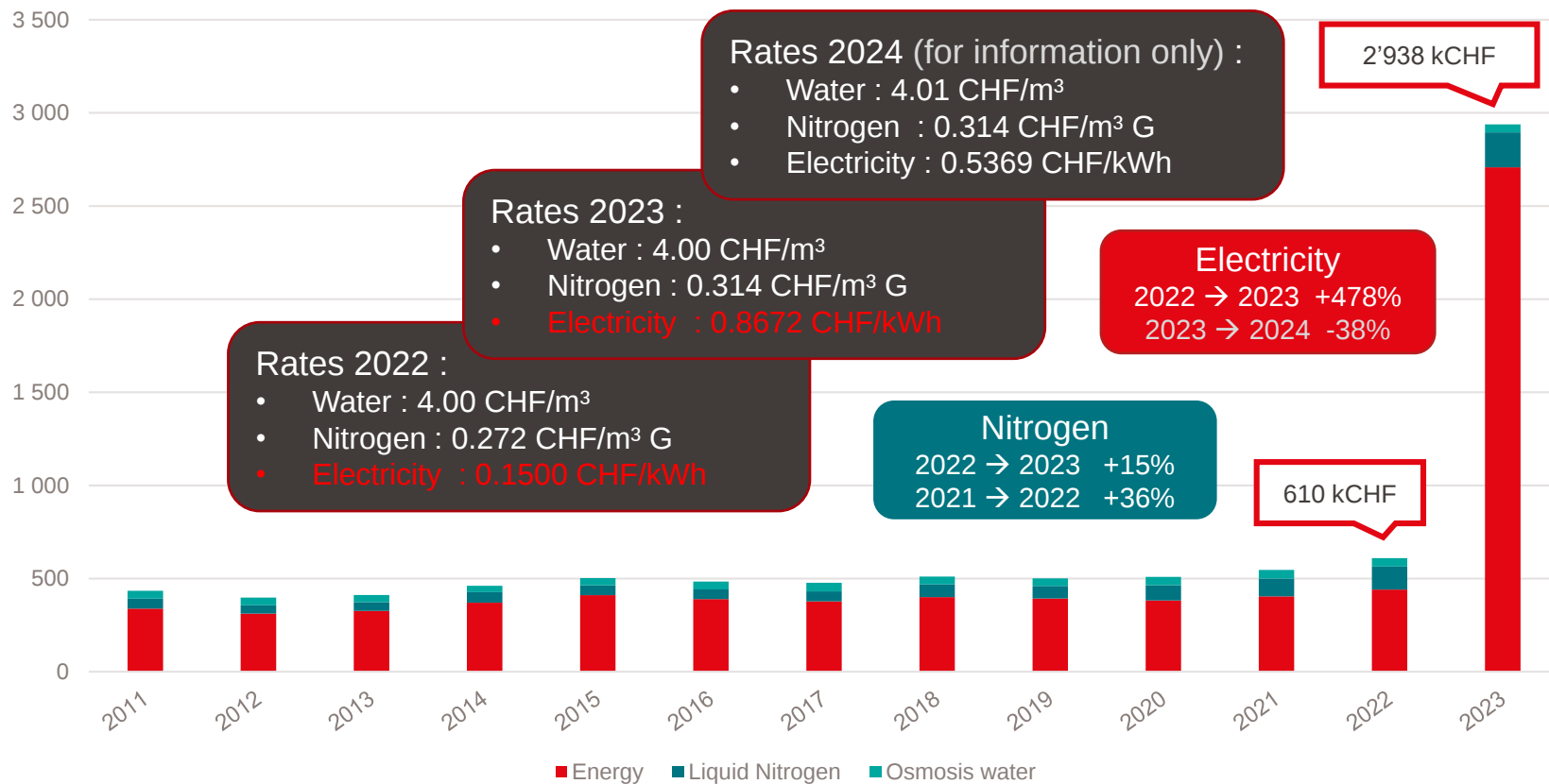
Energy MWh / year

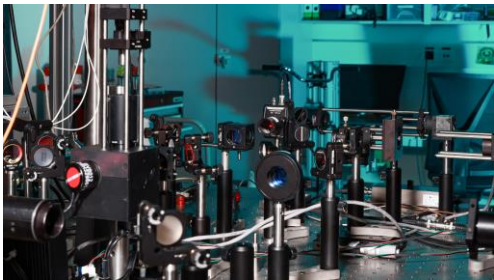
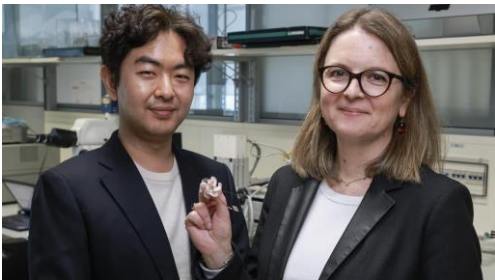
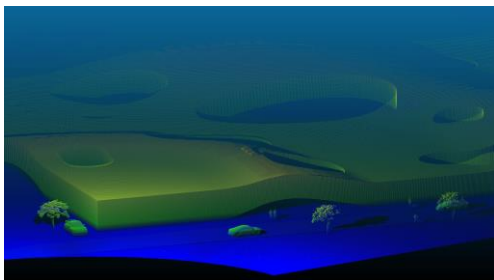
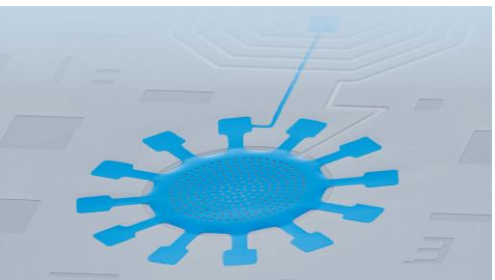
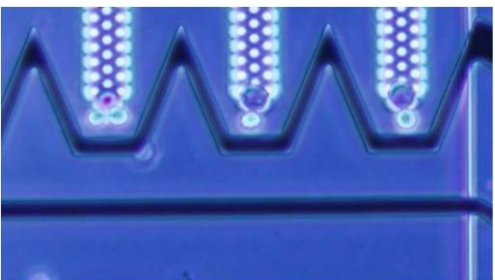


CMi =
7% EPFL

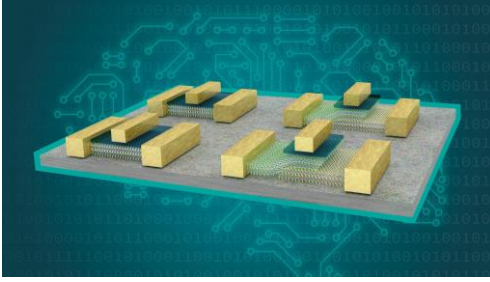
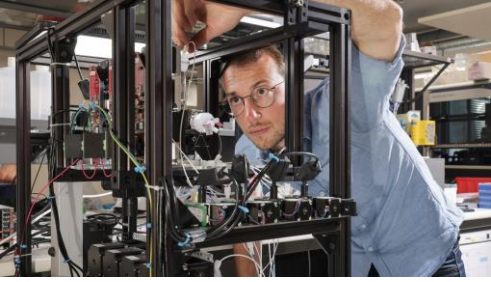
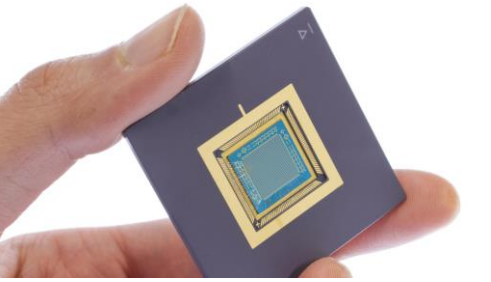
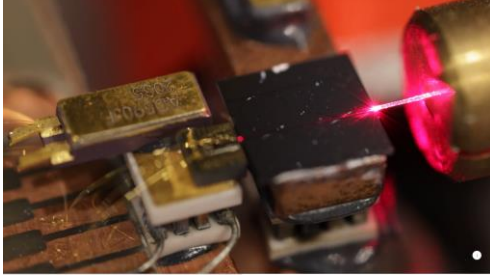
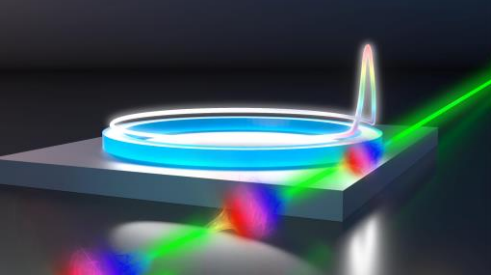
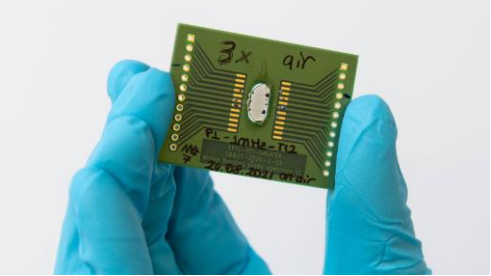
Liquid Nitrogen m³ Gas / yearOsmosis water m³ / year

Fluids & Energy kCHF / year

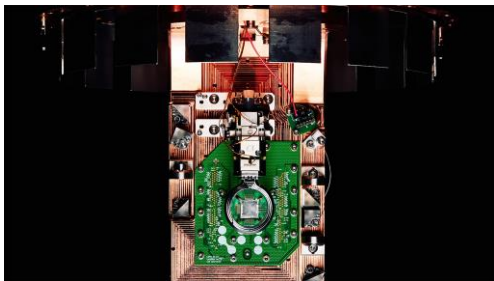
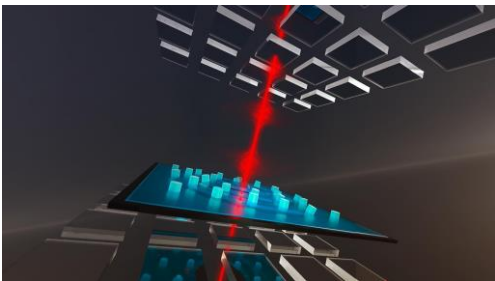
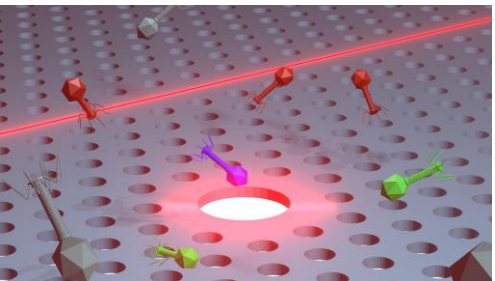
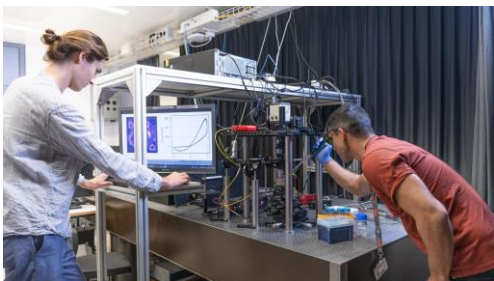
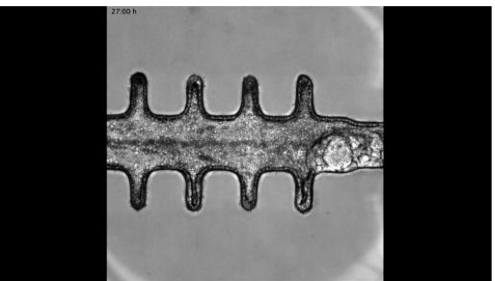


Kis (ELECTRONICS) Nature Photonics https://doi.org/10.1038/s41566-023-01198-w April 2023 	Lacour (NEUROTECHNOLOGY) Science Robotics https://doi.org/10.1126/scirobotics.add1002 May 2023 	Altug & Lashuel (BIOSENSING) Science Advances https://doi.org/10.1126/sciadv.adg9644 July 2023 
Kippenberg (PHOTONICS) Nature Photonics https://doi.org/10.1038/s41566-023-01246-5 July 2023 	Kippenberg (QUANTUM SCIENCES) Nature Photonics https://doi.org/10.1038/s41567-023-02135-y August 2023 	Renaud (LAB ON A CHIP) Lab on a Chip https://doi.org/10.1039/d3lc00400g July 2023 

- A selection of publications which attracted special interest (last 12 months)
- Publication in high impact journals were relayed onto the EPFL home page

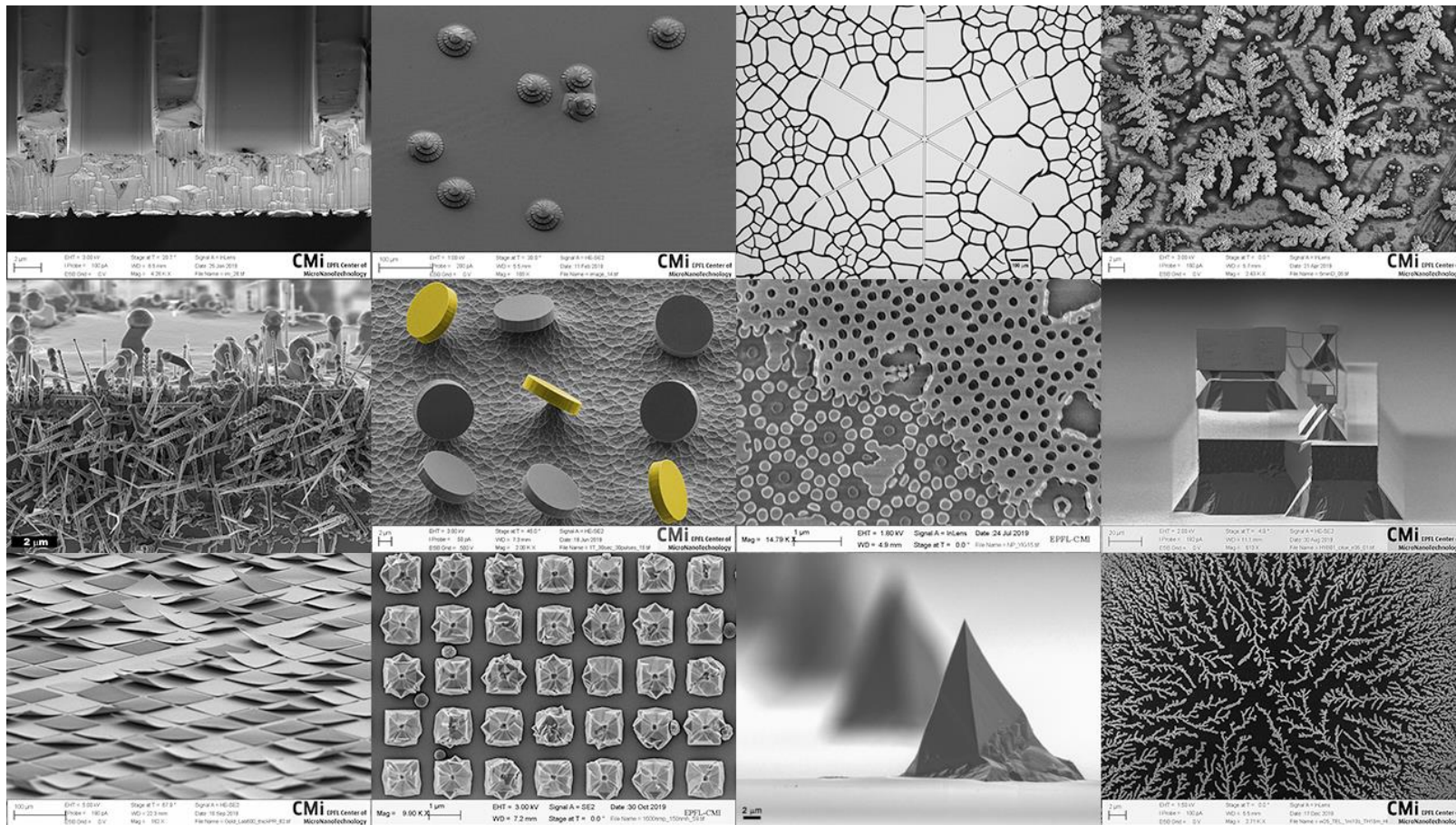
Ionescu & Brugger (MICROELECTRONICS) Nature Electronics //doi.org/10.1038/s41928-023-01018-7 August 2023	Parithera EPFL (LAB ON A CHIP) EPFL spin-off October 2023	Kis (MICROELECTRONICS) Nature Electronics //doi.org/10.1038/s41928-023-01064-1 November 2023
		
Brès and Kippenberg (PHOTONICS) Light: Science & Applications https://doi.org/10.1038/s41377-023-01329-6 December 2023	Kippenberg (PHOTONICS) Science //doi.org/10.1126/science.adk2489 January 2024	Bellouard (MATERIALS) Physical Review Applied https://doi.org/10.1103/PhysRevApplied.21.014008 January 2024
		

- A selection of publications which attracted special interest (last 12 months)
- Publication in high impact journals were relayed onto the EPFL home page

Oxford Ionics (QUANTUM COMPUTING) Press Release £6m contract February 2024	Kippenberg (QUANTUM SCIENCES) Nature https://doi.org/10.1038/s41586-023-06997-3 February 2024	Houdré (LAB ON A CHIP) Small https://doi.org/10.1002/sml.202308814 January 2024
		
Radenovic & Kis (ELECTRONICS) Nature electronics https://doi.org/10.1038/s41928-024-01137-9 March 2024	Tagliabue (ENERGY HARVESTING) Device https://doi.org/10.1016/j.device.2024.100287 March 2024	Lutolf (ORGANOIDS) Nature https://doi.org/10.1038/s41586-024-07330-2 April 2024
		

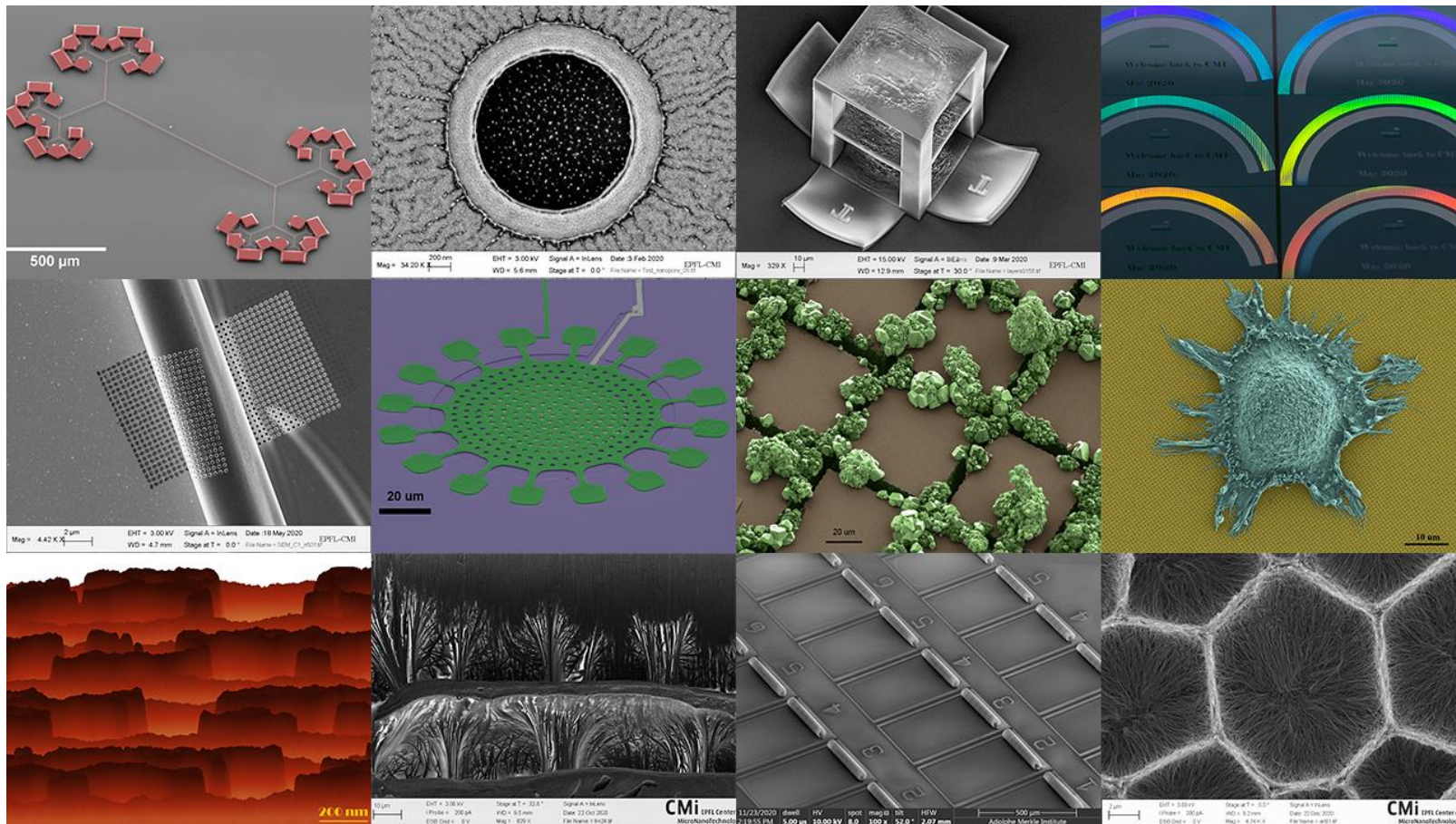
- A selection of publications which attracted special interest (last 12 months)
- Publication in high impact journals were relayed onto the EPFL home page

Picture of the month 2019

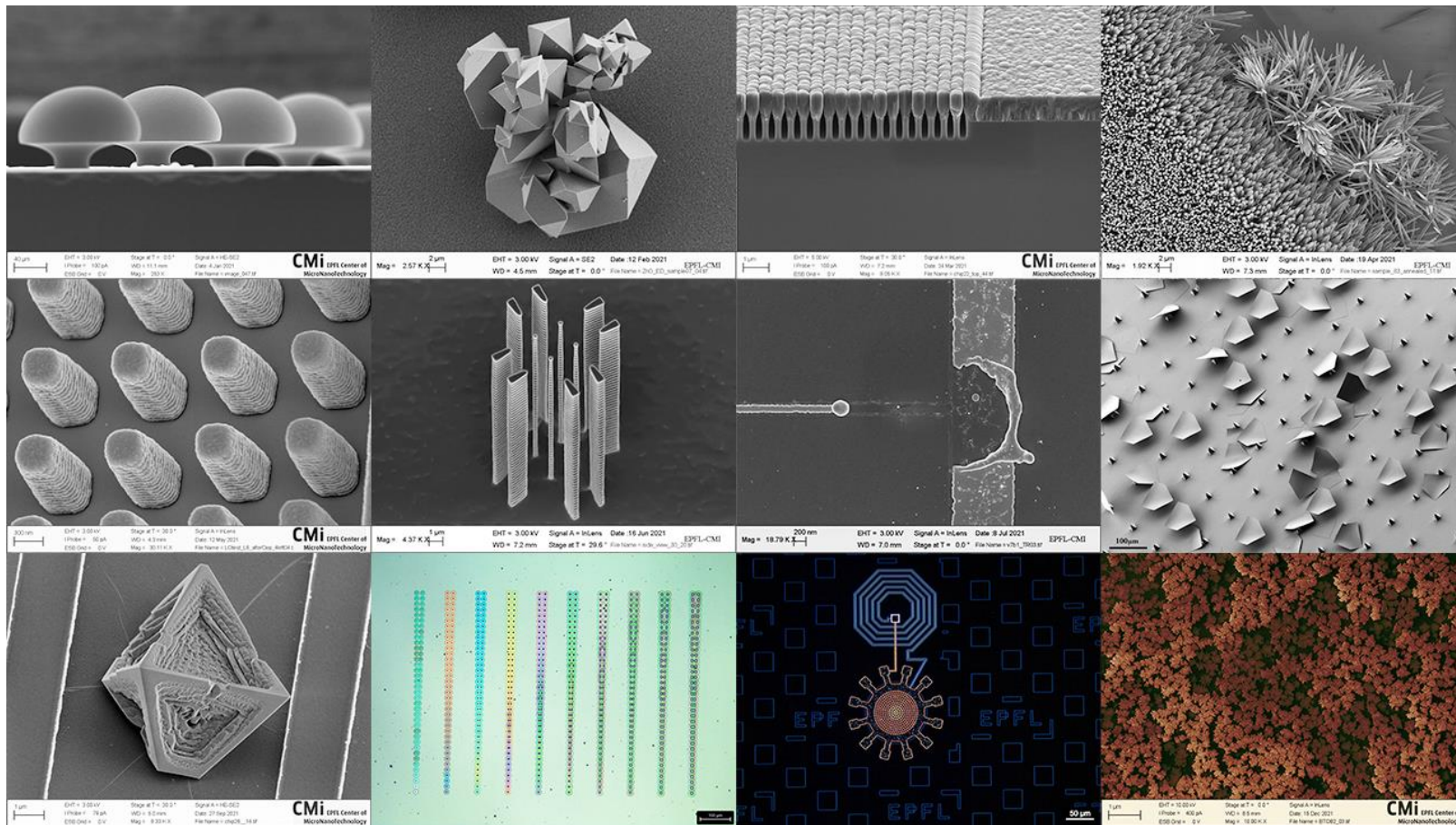


For the pleasure of the eyes : the official winners of the monthly picture contest

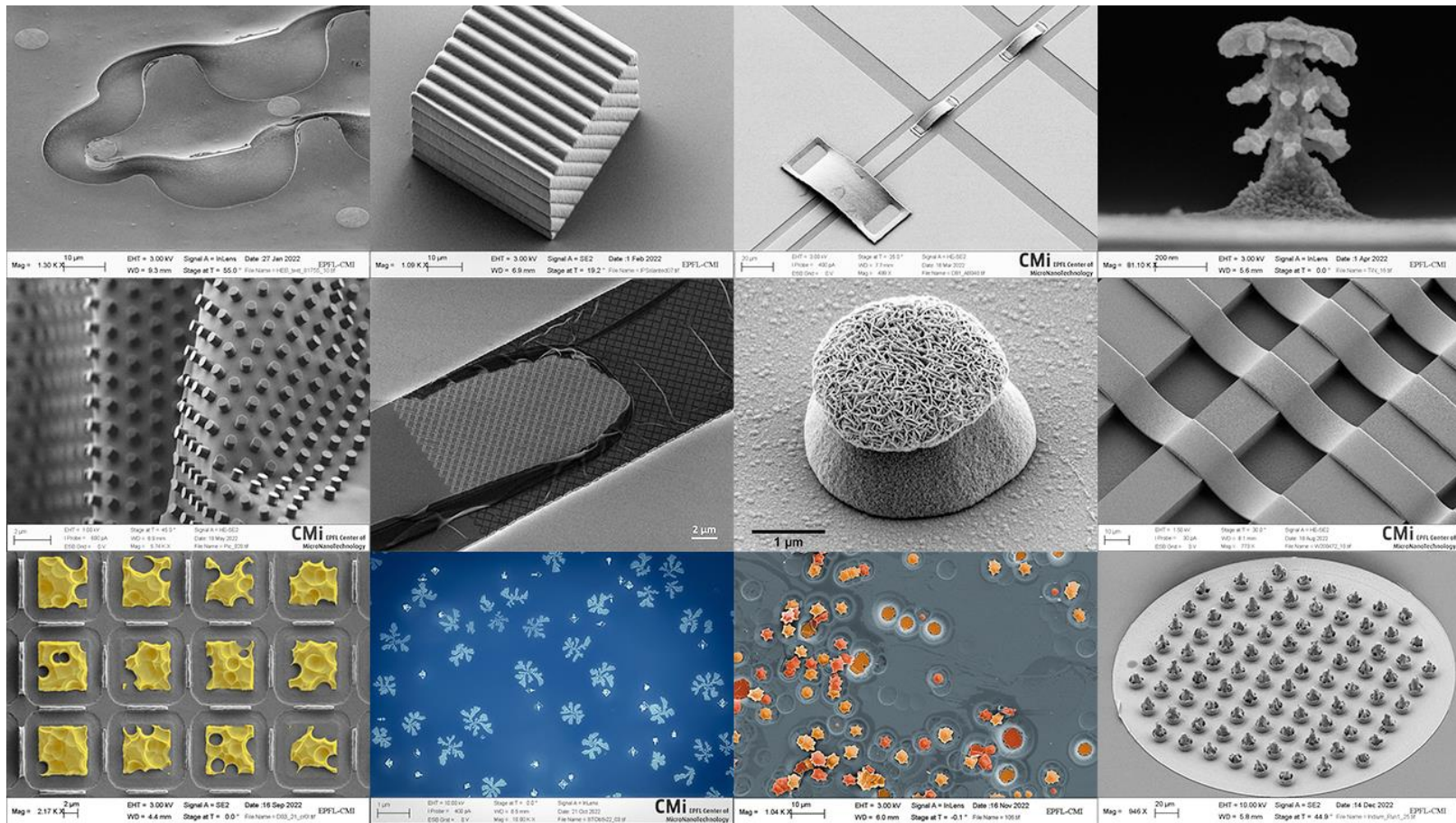
Picture of the month 2020



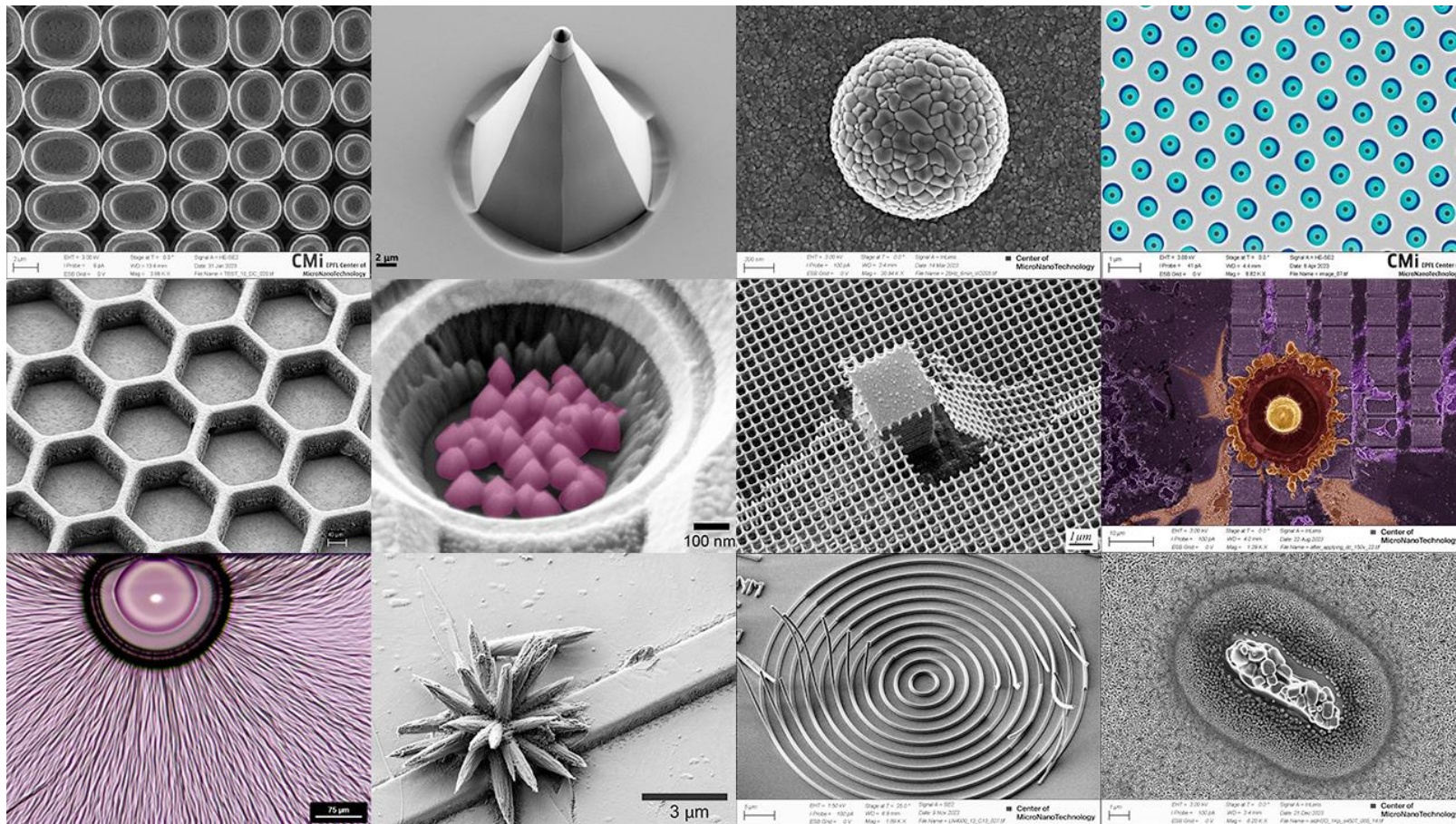
Picture of the month 2021

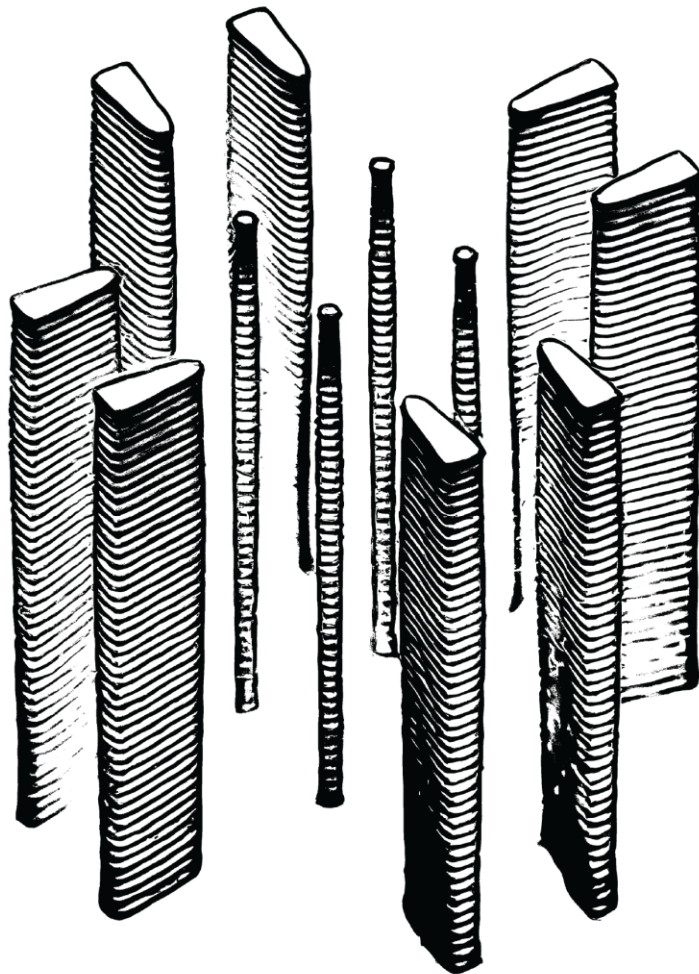


Picture of the month 2022



Picture of the month 2023





List of posters

- The 184 posters presented today are available online
- Password is available on request
- A few paper brochures are available

<https://cmiaccess.epfl.ch/projects/>



TUESDAY, 14 MAY 2024

09:00 - 10:00

Coffee and Croissants & Registration & Exhibit Inspection

10:00 - 10:15

**Philippe Flückiger, Director**
Introduction
Center of MicroNanoTechnology (CMi) [?]

10:15 - 10:30

**Prof. Tobias Kippenberg**
Next generation integrated photonic circuits
Laboratory of Photonic Integrated Circuits and Quantum Measurements (K-Lab) - EPFL [?]

10:30 - 10:45

**Prof. Stéphanie Lacour**
Thin-film and long-term neural electrodes
Laboratory for Soft Bioelectronic Interfaces (LSBI) - EPFL [?]

10:45 - 11:00

**Gerhard Lammel, Director System Architecture**
The air that we breathe: particulate matter sensing reinforced, ultra small and fanless
Bosch Sensortec GmbH [?]

11:00 - 11:30

Coffee Break & Poster Session & Exhibit Inspection

11:30 - 11:45

**Prof. Zhengmao Lu**
Nanoporous membrane device for high flux phase change cooling
Energy Transport Advances Laboratory (ETA-Lab) - EPFL [?]

11:45 - 12:00

**Prof. Elison Matioli**
Electronics at the Edge: Breakthroughs for Efficient Power Devices and the Next Wave of Terahertz Electronics
Power and Wide-band-gap Electronics Research (POWERLab) - EPFL [?]

12:00 - 12:15

**Prof. Jürgen Brugger**
Can micro/nanofab education go digital?
Microsystems Laboratory (LMIS) - EPFL [?]

12:15 - 14:30

Lunch & Poster Session & Exhibit Inspection

14:30 - 14:45

**Prof. Adrian Ionescu**
Beyond Classical Computing: how Neuromorphic and Quantum technologies are paving the way for future AI
Nanoelectronic Devices Laboratory (NanoLab) - EPFL [?]

14:45 - 15:00

**Prof. Anna Fontuberta**
Nanopatterning to enable new materials and structures, applications in photovoltaics and quantum technologies
Laboratory of Semiconductor Materials (LMSG) - EPFL [?]

15:00 - 15:30

Coffee Break & Poster Session & Exhibit Inspection

15:30 - 15:45

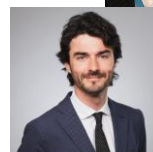
**Julien Arcamone, VP of Corporate R&D**
ALD (Atomic Layer Deposition) and Si/SiGe epitaxy as key enablers of advanced logic and memory devices
ASM International Nix [?]

15:45 - 16:00

**Prof. Philippe Renaud, Professor Emeritus**
Prof. Nico de Rooij, Professor Emeritus
MEMS in CH - some historical perspectives

16:00 - 18:00

Cocktails & Poster Session & Exhibit Inspection



Program

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

Scan the QR code to
access the Program



Exhibitors

- 48 companies
- Thank you to all of them

Donation

- Ligentec contributed a donation to support the maintenance of the LPCVD and DUV tools.

- Thank you to all our exhibitors
- Thank you to Ligentec for its generous donation of 100kCHF (05.01.2024)



“Alone we can do so
little, together we
can do so much.”

Merci

Enjoy the conference
Thank you for your attention

Philippe Flückiger

**EPFL
CMi**



Merci

Enjoy the conference
Thank you for your attention

Philippe Flückiger