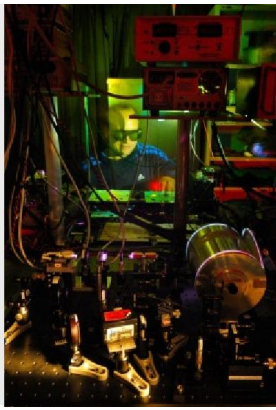
SWISS PHOTONICS

National Fiber Laboratory - SNFL

DIAMOND
the fiber meeting

Connectors for Advanced Fiber Systems: Introduction

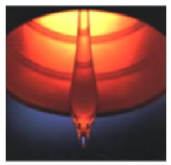


Valerio Romano

Losone, June 26, 2014

Bern University of Applied Sciences

UNIVERSITÄT BERN



In cooperation with the CTI

KTT-Support
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Schweizerische Eidgenossenschaft
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Confederaziun svizra

Swiss Confederation

Commission for Technology and Innovation CTI

Content

1. Driving forces for growth in fiber markets
   – Energy consumption of data centers
   – Specialty optical fibers
   – ...

2. Swissphotonics National Fiber Laboratory SNFL

3. Short overview of labs at IAP Bern

1.1 Data Centers' need for el. power...

DATA CENTRE

IT now 10 percent of world's electricity consumption, report finds

New analysis finds IT power suck has eclipsed aviation

By Jack Clark, 16 Aug 2013 Follow 4,865 fol

North America

Rank		2012	2013	% Increase
1st	Canada	910	990	8.8%
2nd	USA	9,900	10,560	6.7%
	NAM	10,810	11,550	6.8%

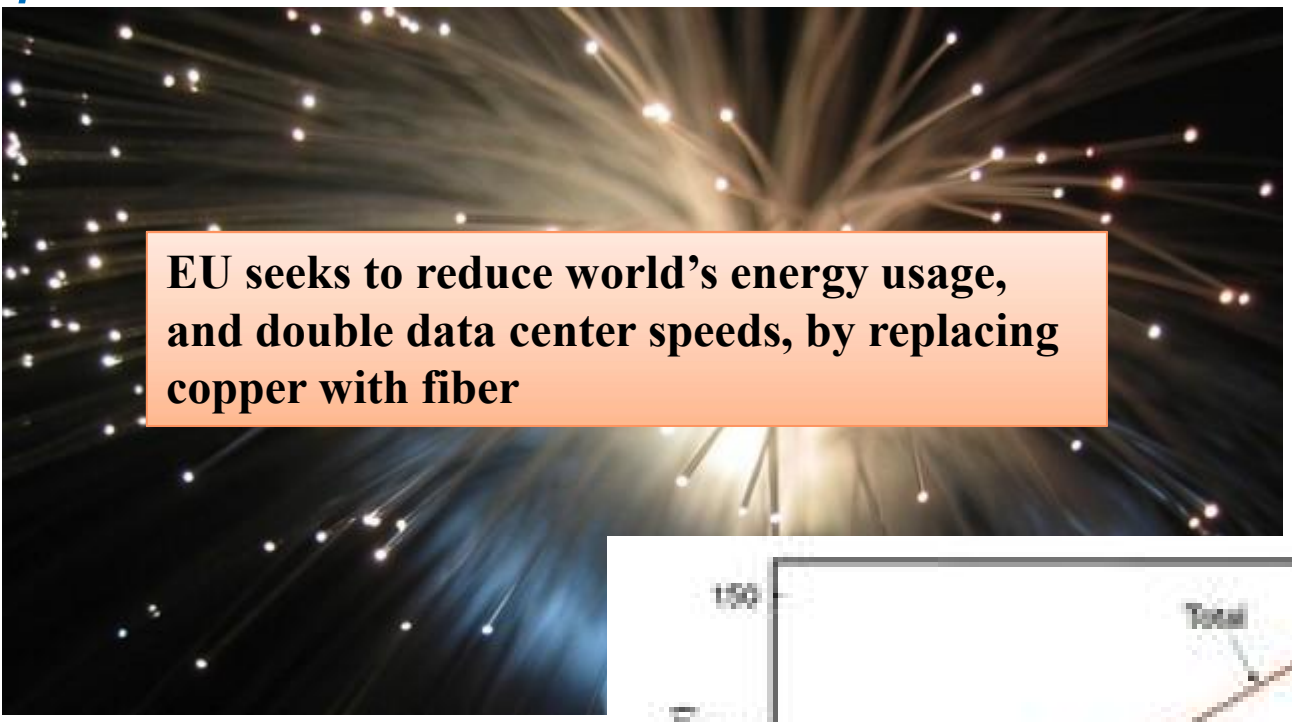
Europe

Rank		2012	2013	% Increase
1st	Poland	90	120	33.3%
2nd	Turkey	135	175	29.6%
3rd	Russia	860	1,005	16.9%
4th	Other markets	340	390	14.7%
5th	Nordics	440	500	13.6%
6th	UK	2,850	3,100	8.8%
7th	Switzerland	370	400	8.1%
8th	Germany	2,700	2,850	5.6%
9th	France	1,650	1,730	4.8%
10th	Netherlands	820	845	3.0%
11th	Belgium + Lux	300	305	1.7%
12th	Spain	1,000	960	-4.0%
13th	Italy	1,150	1,090	-5.2%
	EUROPE	12,705	13,470	6.0%

Total datacenter power needs (world, in MW):

	Total	36,245	38,840	7.2%

1.2 ... increases need for fibers, components and silicon photonics that interfaces with fibers



EU seeks to reduce world's energy usage, and double data center speeds, by replacing copper with fiber

/100 for fiber -SiPhot

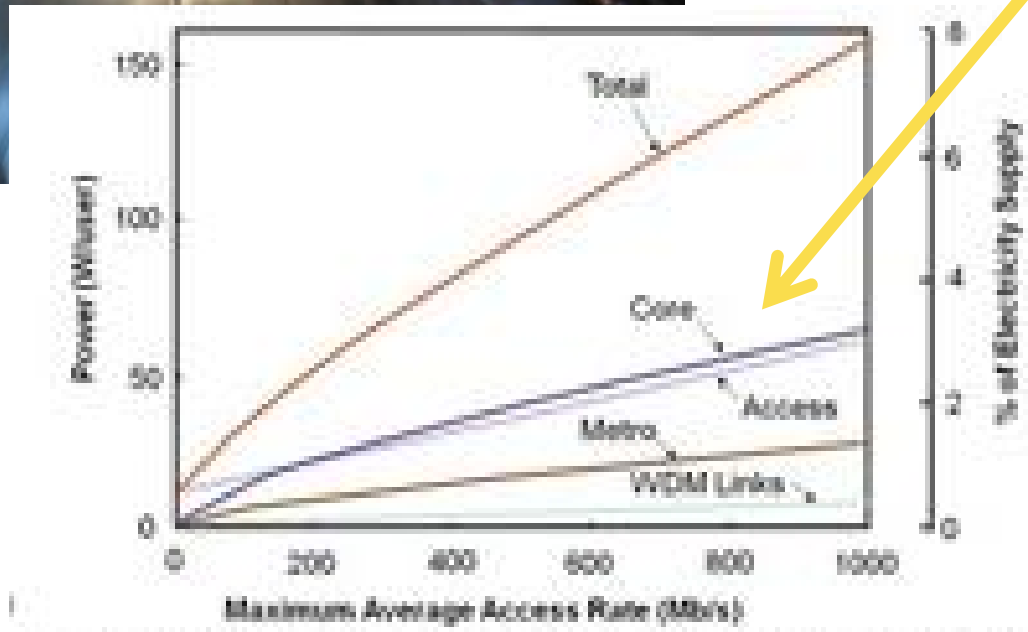


Fig. 2. Components of power required to run the Internet[3].

1.3 2nd driving force: Specialty optical fibers

- **Size of complete specialty optical fibers market** (incl. sensor fibers, active fibers, microstructured opt. fibers) : **1'000 M$**
- **Continuous growth in high power active fibers** for fiber lasers (100M$), fibers for sensing and MOFs
- **Specialty optical fibers** are of different glass materials and shapes -> need connectors to combine different fibers and functionalities

1.4 Fiber Systems, Lasers: «All-In-Fiber»

- One strength of fiber systems: no alignement and service as long as all in fiber
  - connectors can be a key component

- Weakness of fibers: some optical effects are difficult to be obtained in fibers (eg. 2nd harmonic generation, electrooptical switching,...)
  - integrate these functionalities in connectors.

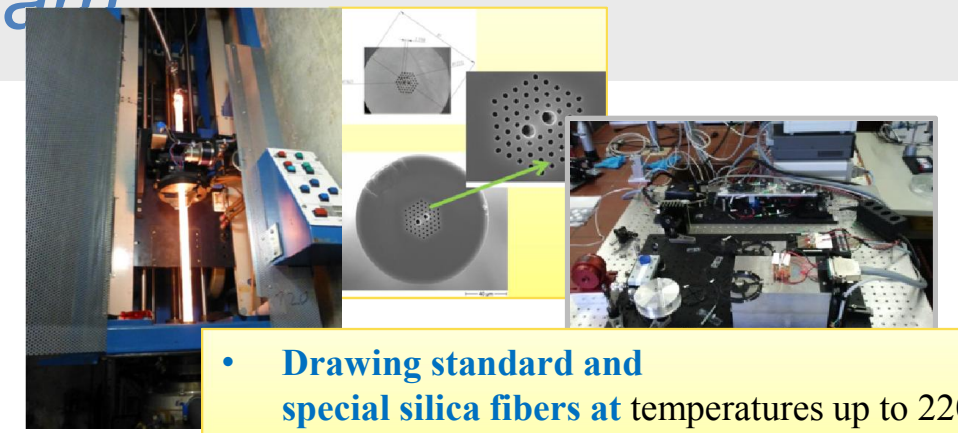
2.1 SNFL and its goals

- Gather the expertise in Switzerland in the field of fibers, fiber lasers and applications
- Offer:
  - design of active / passive / microstructured fibers
  - drawing of fiber prototypes (Fiber Rapid Prototyping)
  - fiber characterisation
  - development of applications
    - beam delivery, shaping
    - light sources
    - fiber lasers
  - interfacing («all in fiber», fiber<>integrated systems)
- Despite the absence of industrial fiber drawing capability in Switzerland

2.2 SNFL Team (from west to east)

- EPFL, Group for Fiber Optics (GFO), Luc Thévenaz
- EPFL, Laboratory of Photonic Materials and Fibre devices (FIMAP), Fabien Sorin
- University of Bern, Institute of Applied Physics (IAP), Fibers and Fiber Lasers Group, Manuel Ryser (V. Romano)
- Bern University of Applied Sciences, ALPS, Applied Fiber Technology group, Valerio Romano (Contact person)
- Fachhochschule Ostschweiz (NTB), Institute for Micro- and Nanotechnology - Photonics group, Markus Michler

2.3 SNFL Team

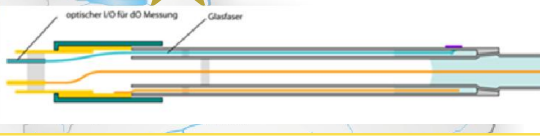


- **Drawing standard and special silica fibers at** temperatures up to 2200°C
- Fiber Lasers
- Delivery fibers

NTB MNT Photonics

BUAS ALPS AFT

Uni BE IAP



Sensors
incl. distributed sensing

EPFL GFO

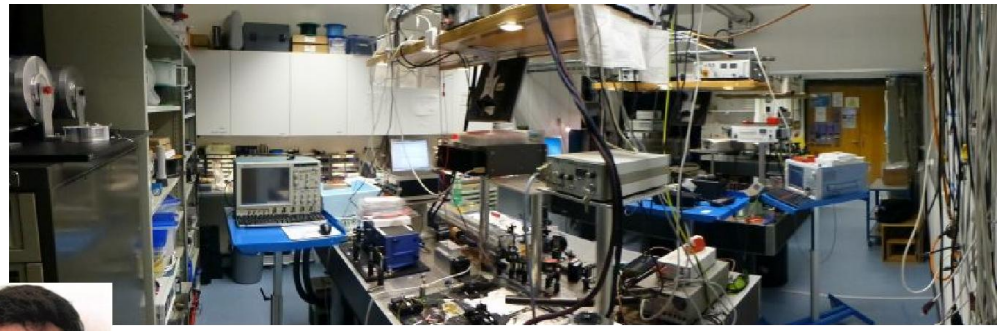
EPFL FIMAP

Drawing special fibers
at temperatures up to 500°C (polymer fibers) and 1100°C (soft glasses)

Fiber optics

- Fiber Assembly (splices / connectors)
- Fiber Packaging (bundles / GRIN packages)
- Fiber Sensors

3.1 People and labs IAP BE and BUAS Burgdorf



Collaboration between:
Inst. of Appl. Physics, IAP Uni Bern
and Inst. for Applied Lasers,
Photonics and Surface Technology
ALPS of BUAS:

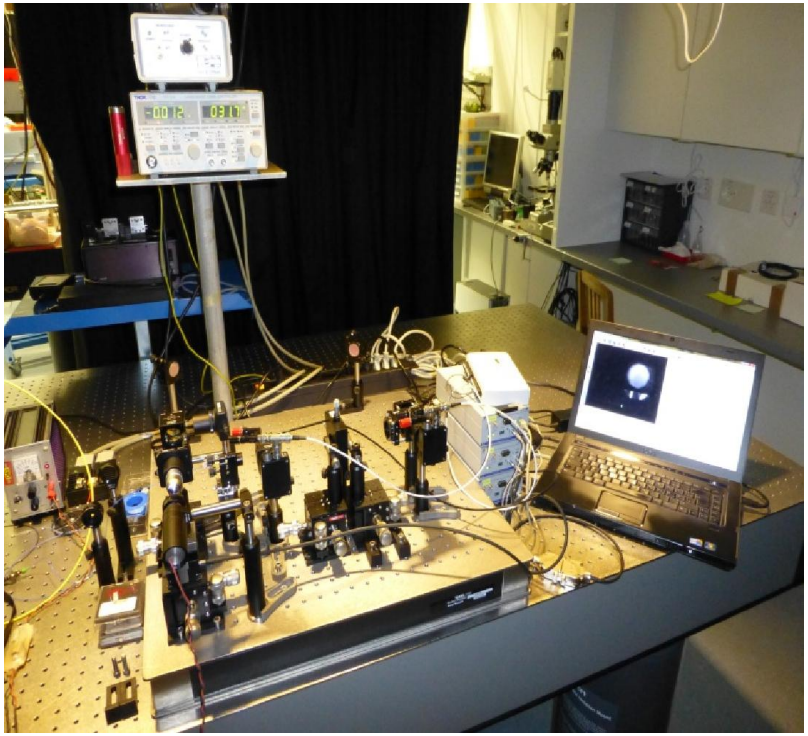
applications of modern fibers

- fiber lasers and amplifiers
- materials processing,
- sensing, metrology,
- light sources
- fiber beam delivery
- beam shaping

Two labs: one in Bern,
one in Burgdorf

At present: 11 people

3.2 Fiber Characterisation, processing, handling



R.I.P.: 1D- Refractive index profiler
(Master Thesis Jonas Scheuner, IAP Bern)

2D-version: Bachelor thesis at BUAS

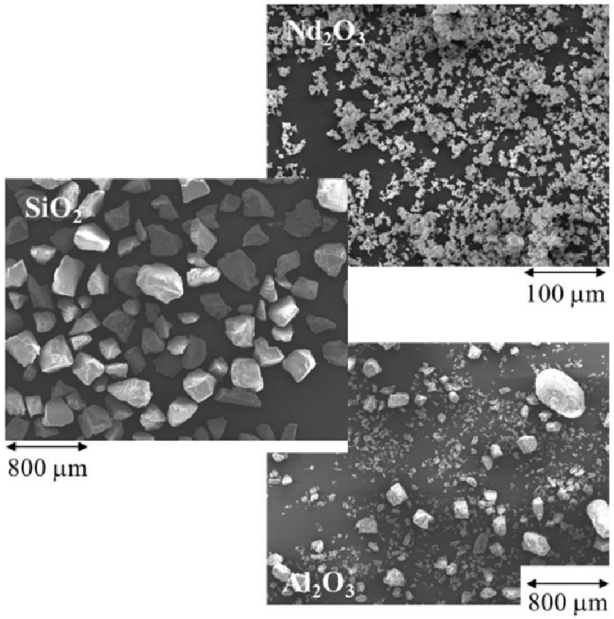
Characterisation:

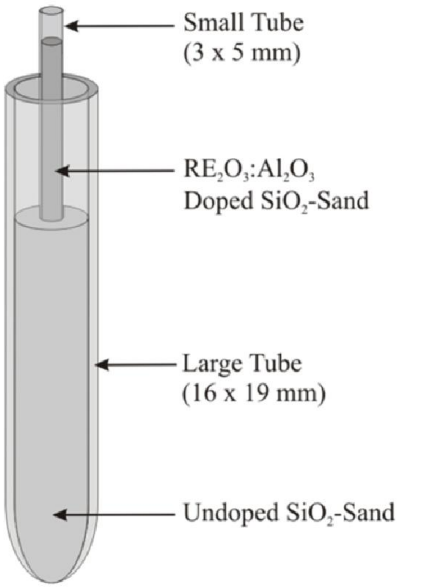
- Losses
- Spectroscopy
- Index profile

Processing:

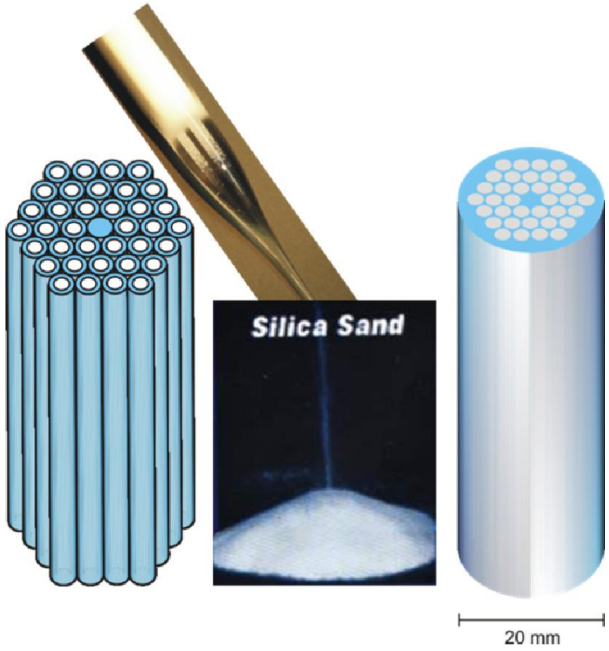
- Cleaving
- Splicing
- Tapering

3.3 Key tecnology: Fiber Rapid Prototyping



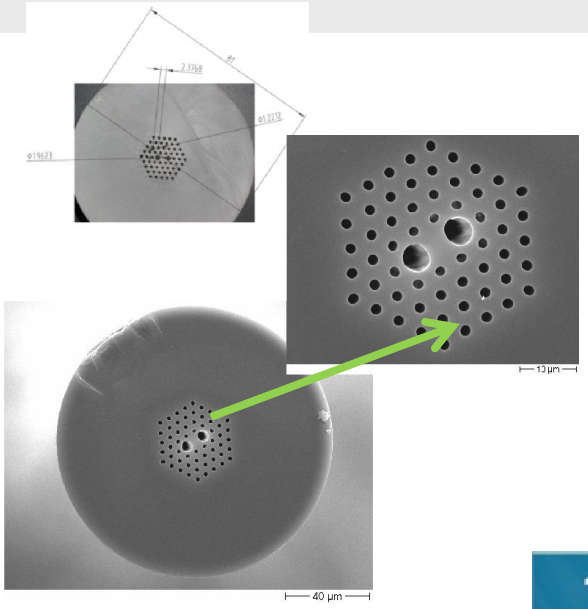


*method patented by Silitec SA, Boudry



Granulated silica is used to produce preforms with any microstructure

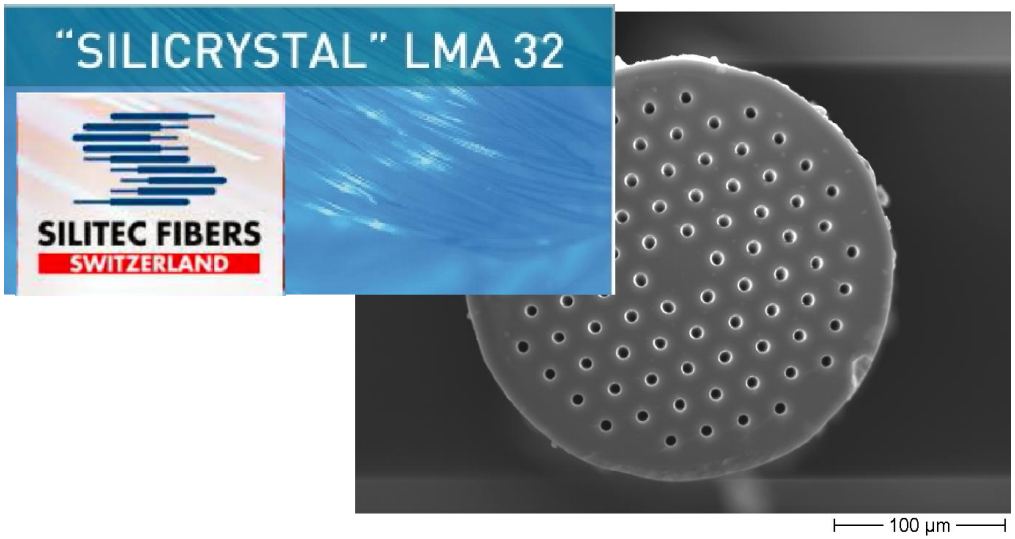
3.4 Example: microstructured fibers



Fiber diameter: 170µm

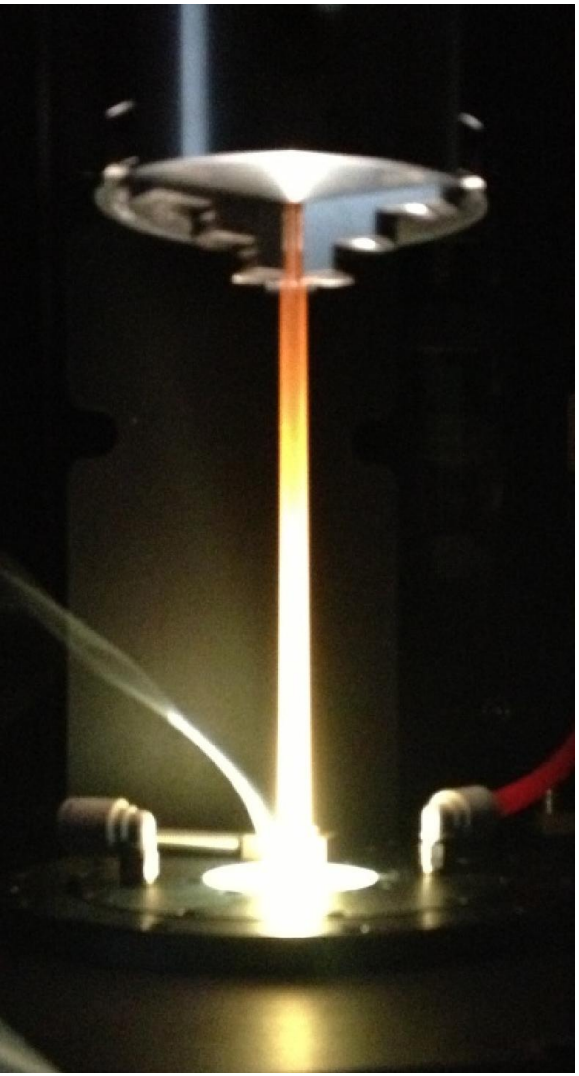
Core diameter (d): 21 µm

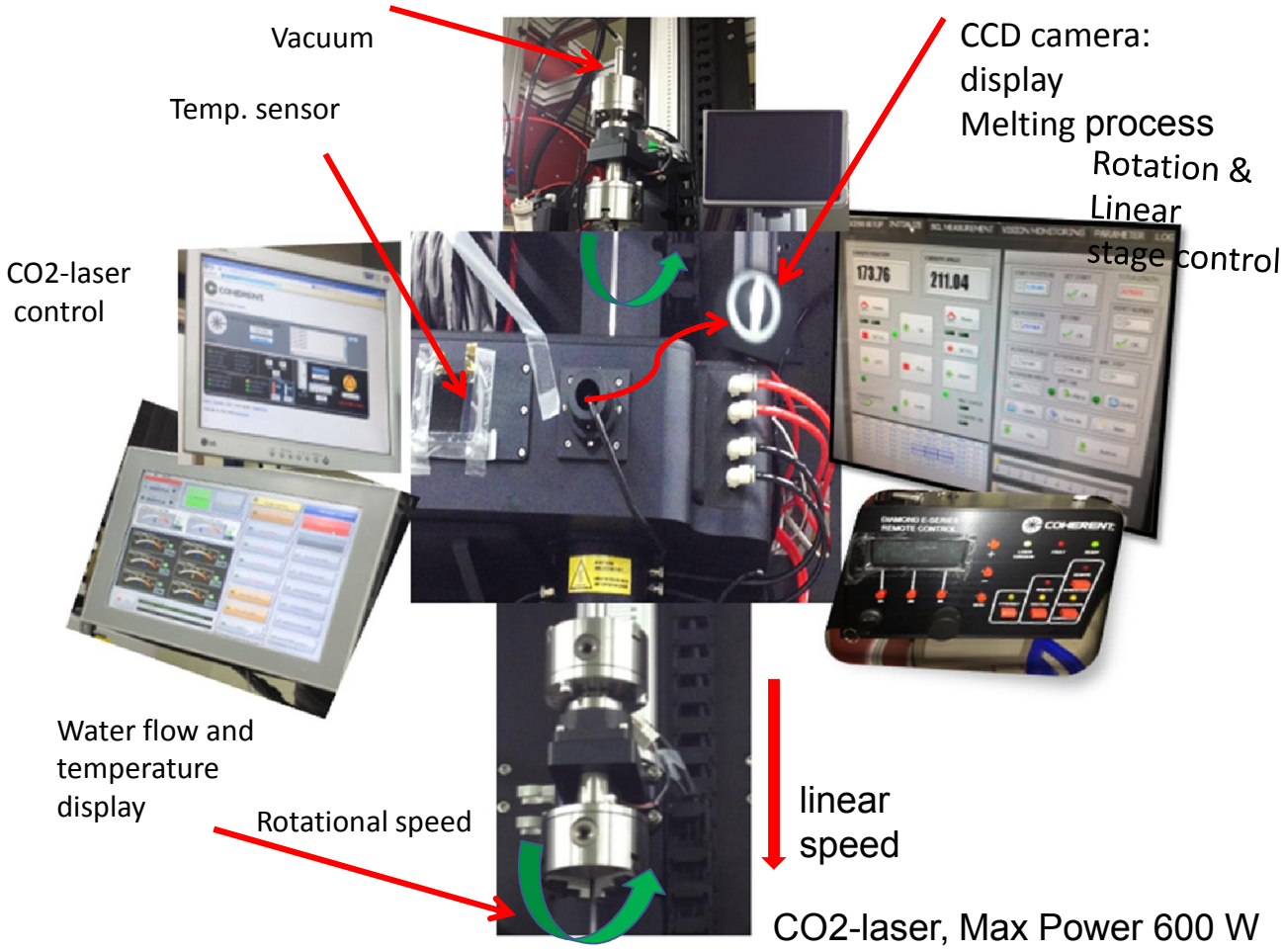
Hole diameter: 7 µm



3.5 Further improvement

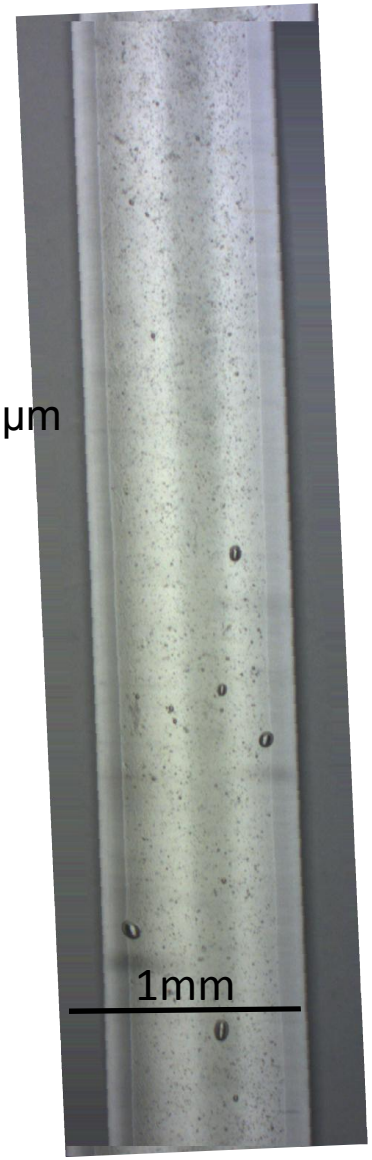
«Traveling Small Zone» (TSZ) Laser Vitrification





3.6 Core rods comparison

- 3 at% Al_2O_3
- 0.2 at % Yb_2O_3
- 2 at% P_2O_5
- SiO_2 :
- grain size 100 -200 µm



5X iterative milling and sintering

3 at% Al_2O_3
2 at% P_2O_5
0.3% Yb_2O_3
grain size ~80 -100

- 7 X iterative milling/ remelting and

> Laser-based travelling small zone vitrification

3.8 Losses of Powder in tube fibers

Berner Fachhochschule
Haute école spécialisée bernoise
Bern University of Applied Sciences

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Method	Who	Losses	Remarks
Granulated Silica, unvitrified	IAP	1-5 dB/m @633nm	
Fine powder	XLIM/IAP	1 … < 0.1 dB/m	Evacuation difficult
Granulated Silica, not remelted, vitrified	IAP	0.8 dB/m @633 nm	Much better for undoped material
Sol-Gel granulated silica, remelted, vitrified regularly	IAP	0.35 dB/m @633nm	Some bubbles (fiber piecewise good)
Powder in tube, stack and draw	FORC, RAS	0.1 dB/m @1200 nm	
Sol-Gel Granulated Silica, TSZV	IAP	0.2 dB/m @633 nm	***0.035 dB/m@ 1100nm ?***

I wish you a fruitful Workshop and
many interesting discussions