



Berner Fachhochschule
Haute école spécialisée bernoise
Bern University of Applied Sciences

SWISS  PHOTONICS



Photonics: the discipline that is making manufacturing smart

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- ▶ Institute for Applied Laser, Photonics and Surface Technologies ALPS, Fiber Technology Laboratory

Overview

- Short information on "Photonics" MSE Master
- Some thoughts on "smartness"
- Examples of devices that might be used to implement smartness in laser based machines

Introduction

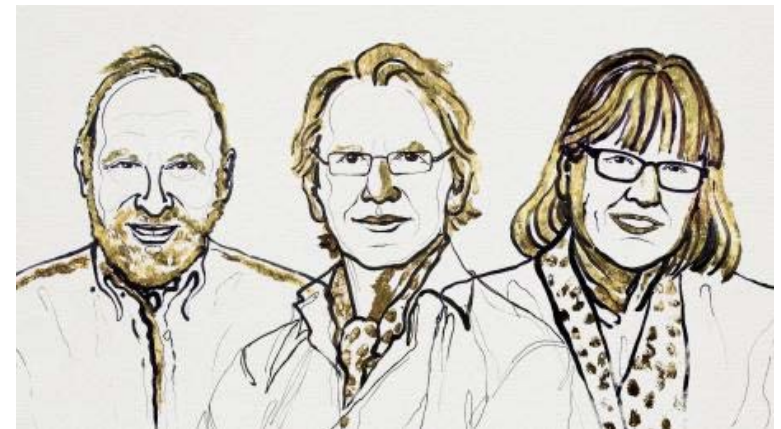
- 2018: important year for photonics in Switzerland:
 - Industry has given strong signals of commitment towards photonics as a key enabling technology ALSO in Switzerland
 - teaching (MSE Master is being prepared as a profile and will start in 2020
 - profile description is ready; implementation in a course of study will start in January 2019
 - Manufacturing technologies impulse programme
- This workshop:
 - Thinking about how photonics impacts on manufacturing
 - How photonics can be implemented in industry by projects, research and teaching
 - How to find a sustainable and effective implementation in funding

Info: MSE Master Profile Photonics

- Profile description is in course of formulation and very well on track
- 6 of 7 UAS participating
- Early 2019 the modules will be formulated
- The contents discussed (not objected by anybody) are:
 - Photonics for machining and manufacturing
 - Optical measuring
 - Optoelectronics and Electrooptics
 - Photonic systems (including design and simulation)
 - Manufacturing for photonics
- Planned start in fall 2020 (inscriptions 2019)

Photonics and noble prizes...

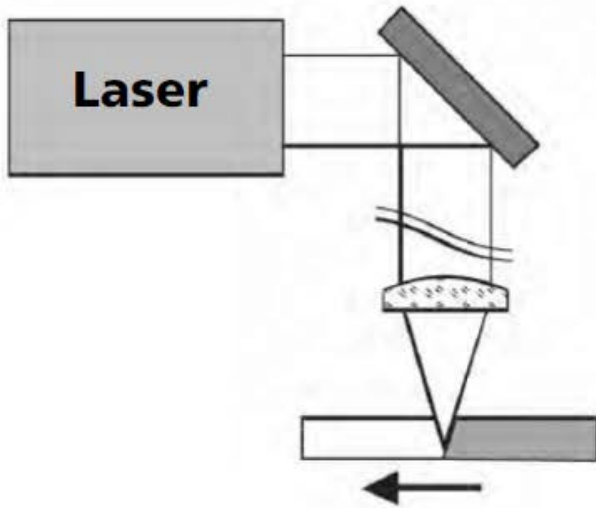
2000	Schores Aljorow	Optoelektronik
	Herbert Kroemer	
	Jack Kilby	Entwicklung des integrierten Schaltkreises
2005	Roy Jay Glauber	optical coherence
	John Lewis Hall	opt. Spektroskopie, Frequenzkamm
	Theodor Hänsch	
2009	Charles Kuen Kao	opt. Glasfaser
	Willard Boyle	„für die Erfindung des CCD-Sensors“
	George Elwood Smith	
2010	Andre Geim	Graphen
	Konstantin Novoselov	
2012	Serge Haroche	Manipulation von Quantensystemen
	David Wineland	
2014	Isamu Akasaki	Blaue dioden
	Hiroshi Amano	
	Shuji Nakamura	
2018	Arthur Ashkin	Laserphysik
	Gérard Mourou	
	Donna Strickland	



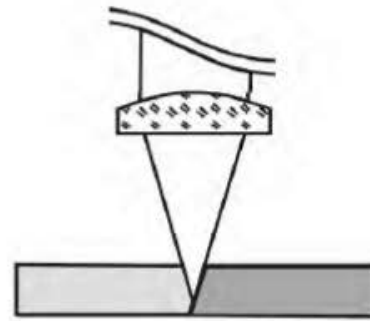
2018

Lasers in production: one tool – many applications

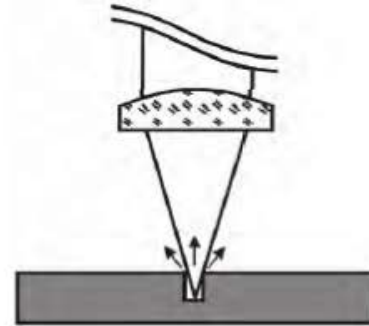
Cutting



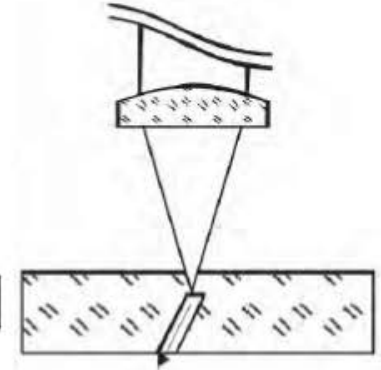
Welding



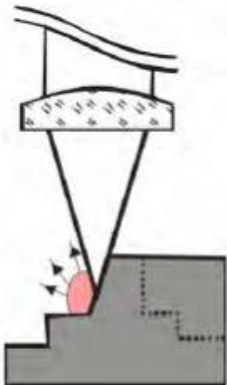
Drilling



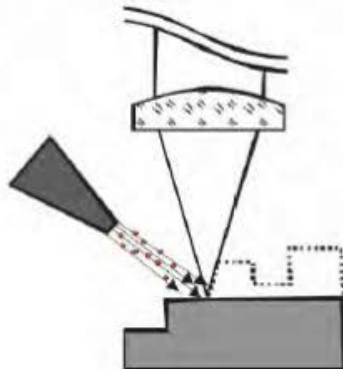
Glass drilling



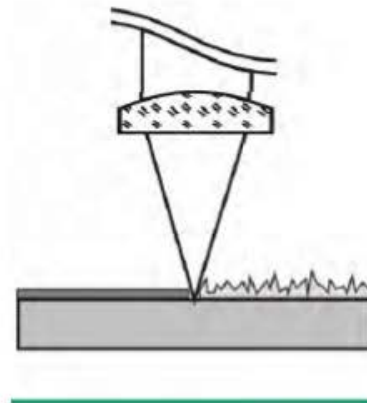
Ablation



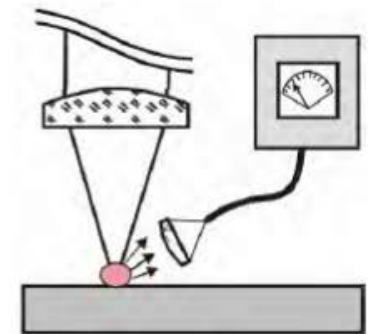
AM



Polishing



Analytics



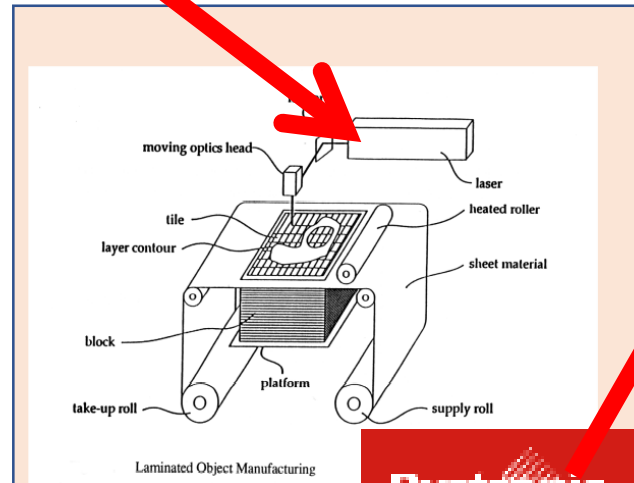
Virtual factory

- *Virtual factory*
- Task: create a factory to produce a symbolic object (Einstein)
- Solution:



Artwork by
Robley Browne

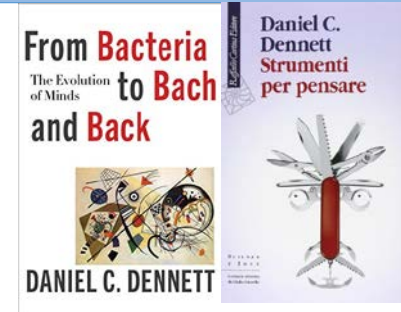
Data reshaping
in our office



On «Bundesplatz»

What does "smart" mean (for a machine or a process)?

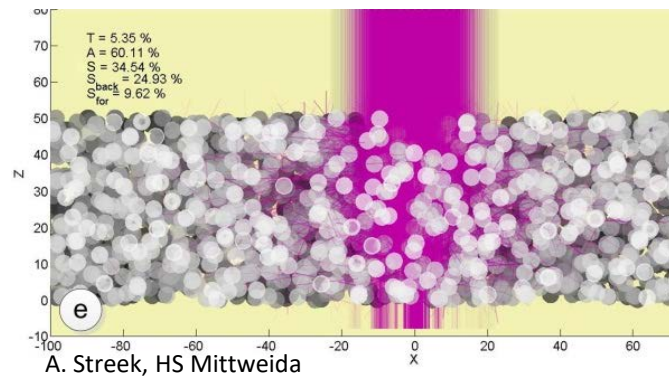
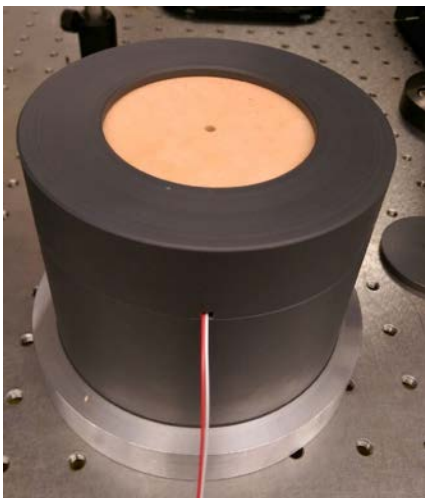
- Some people see spiritual aspects behind intelligence and smartness...
- No philosophical discussion on intelligence here.
- There is no such thing as an "error-free" process
- In a manufacturing process, "smart" might mean to make a process "autonomous", versatile, error tolerant and self repairing. This involves:
 - Fast data collection, very fast data transmission, ultrafast data analysis and feedback;
 - digital storage of the process status;
 - taking repairing measures
 - resuming the process
- So "smart" might mean "Being able to collect big amounts of data very quickly, transferring and analysing them and giving feedback in real time".



Powder characterisation

Projektarbeit «Pulvercharakterisierung»
(PA1) Christian Marti, FS 2016

Optical determination of the laser penetration depth as a function of densification and granulometry of a metallic powder.

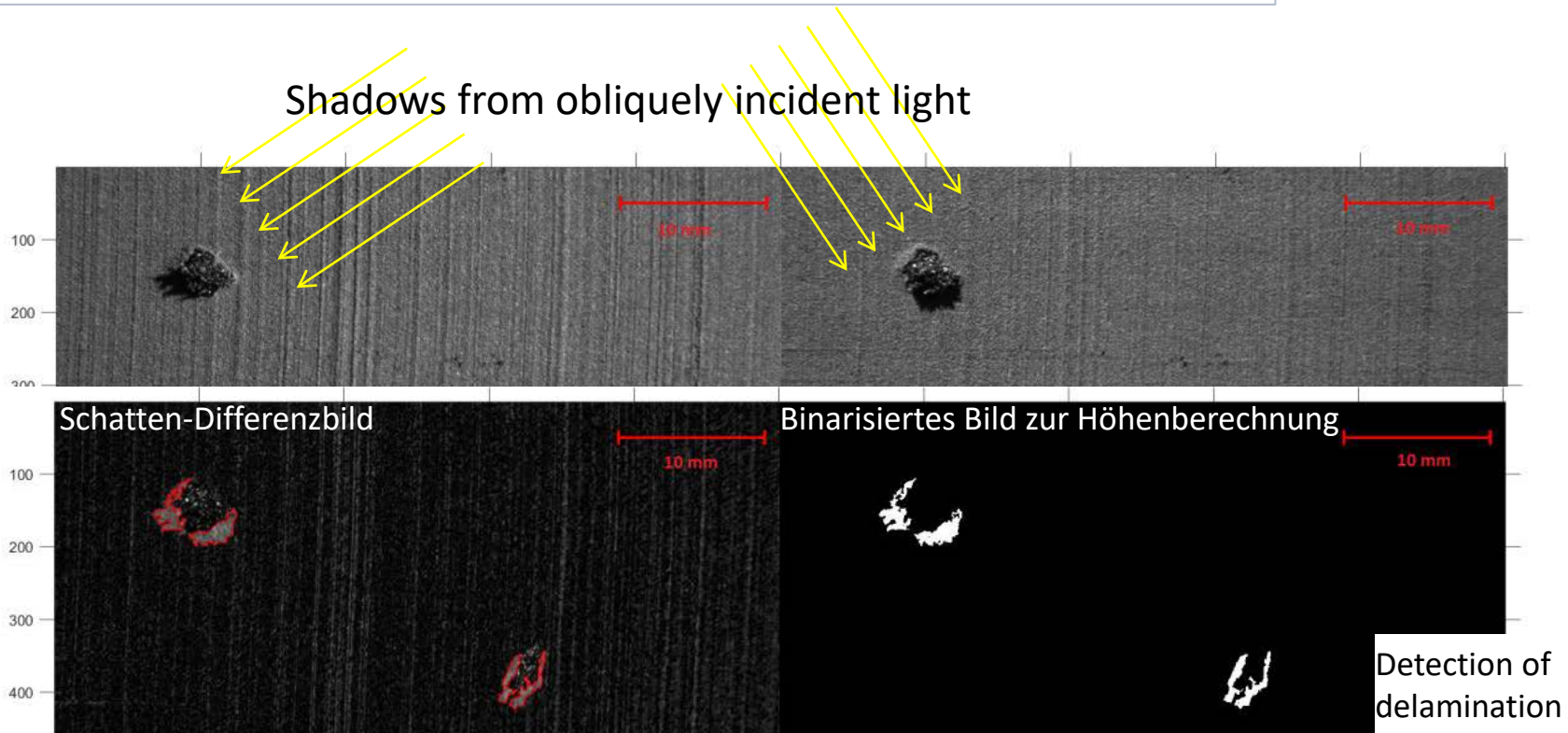


Determination of the heat conductivity of a powder
by a laser probe beam.

Also possible from backscattered data
during the process

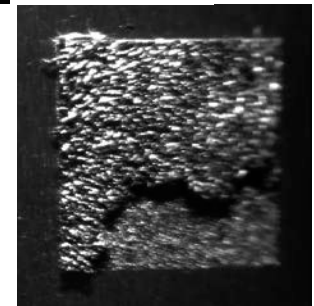
Example: Surface inspection of powder bed

Project work «Visuelle Überwachung des SLM Prozesses»
(PA1) Matthias Fontanellaz, FS 2016



Performance

- Mapping of the complete SLM chamber with 50 μ m resolution
- Min. detection height: 300 μ m Höhe (limited by computer capacity)
- Measurement uncertainty: 23 μ m



Real-time 2D Quotient pyrometry for SLM process

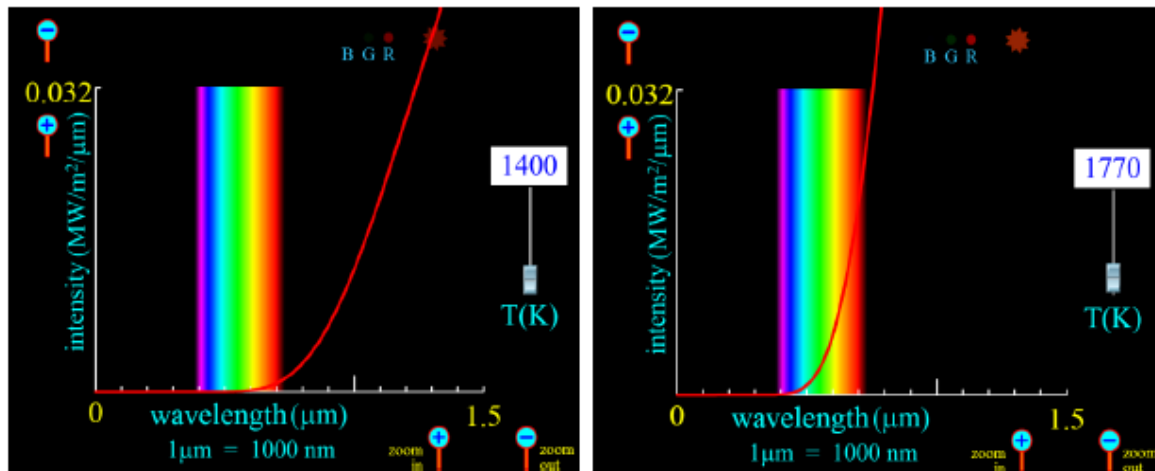
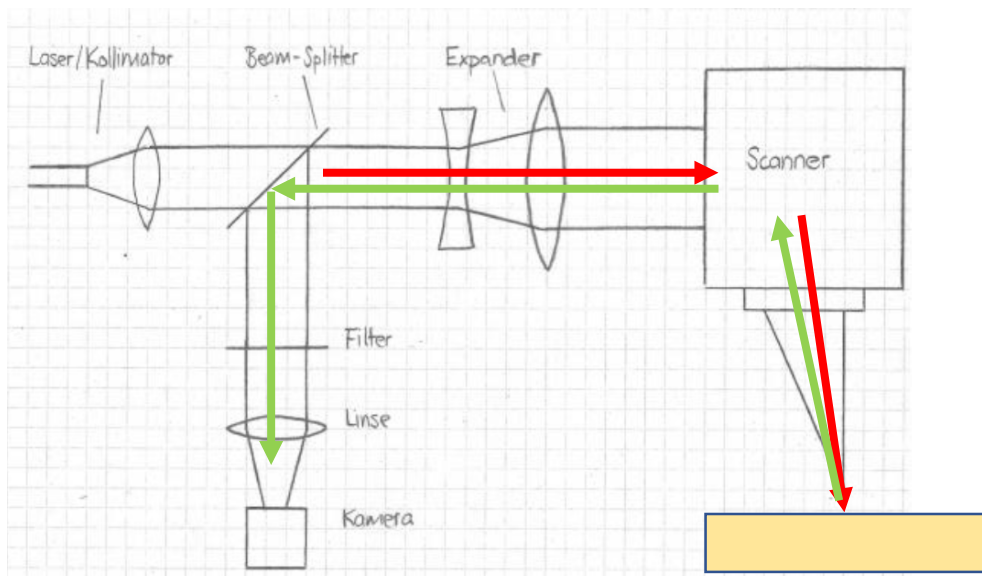


Abbildung 31, Schwarzkörperstrahlung

Temperatures can be measured at wavelengths that are transmitted by the process optics



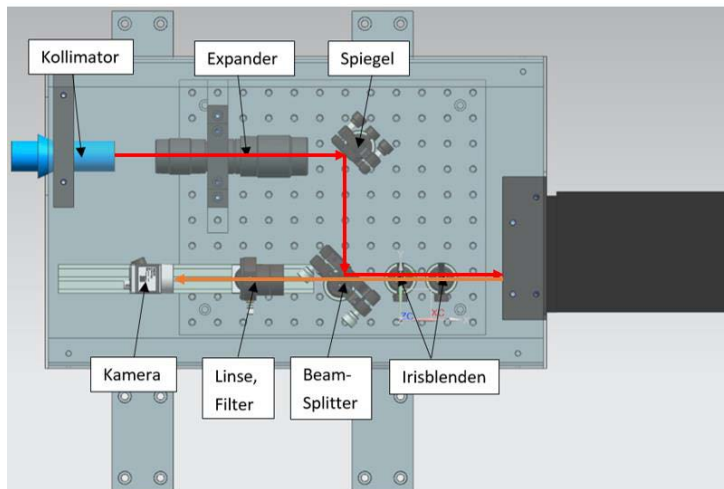
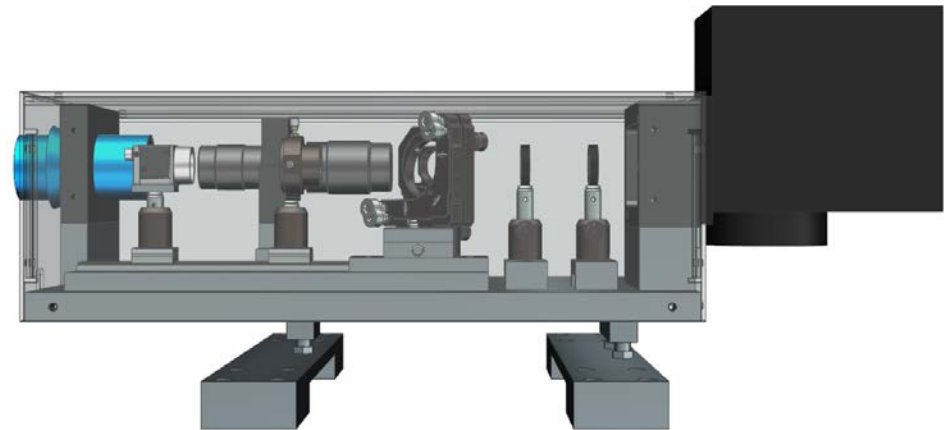
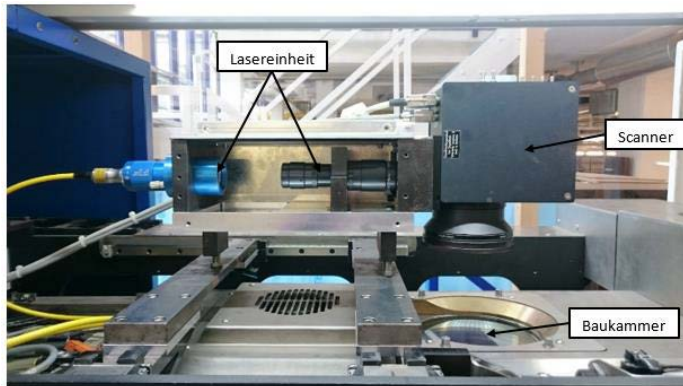
- 2D thermal maps in real-time
- High data rate needed
- Wireless?

SLM real-time thermal process inspection

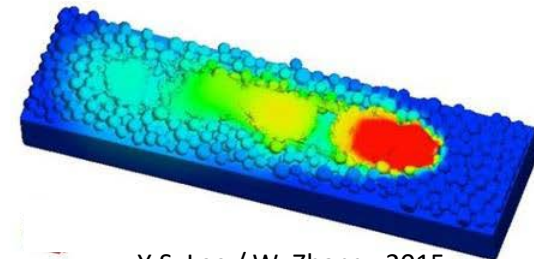
Bachelor Thesis «Real-time Überwachung des SLM Prozesses»

H. Hodak & A. Keller, FS 2016

Master Project work (EVA) Marco Jordi, 2017

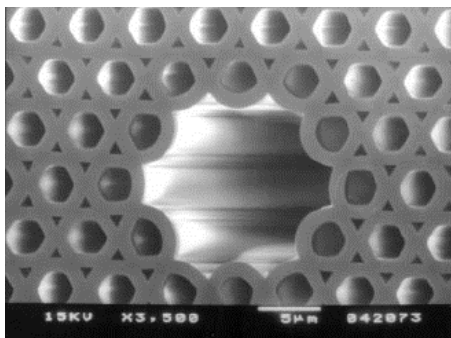


- ▶ Mapping of the temperature distribution in and around the melt pool during laser irradiation
- ▶ Detection of instabilities in the melt pool

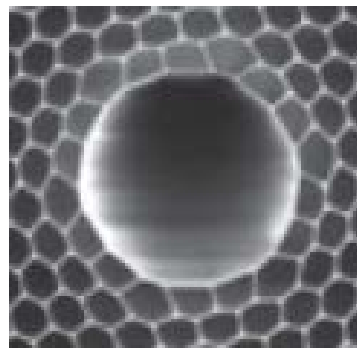


Y.S. Lee / W. Zhang, 2015

Multi-beam delivery through HC fibers



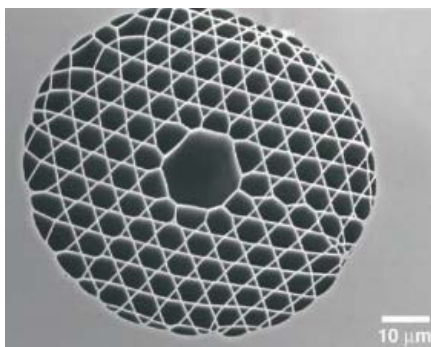
Cregan et al., *Science* **285**, p. 1537, (1999)



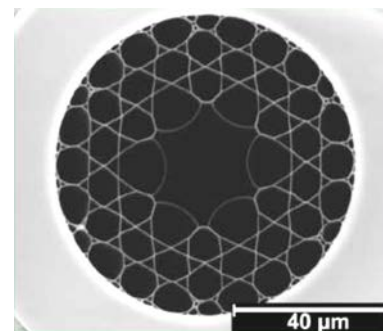
P.J. Roberts et al., *Opt. Express* **13**, p. 236 (2005)

Photonic bandgap fibre

- Ultralow loss
(~1 dB/km demonstrated)
- ~100 nm transmission window



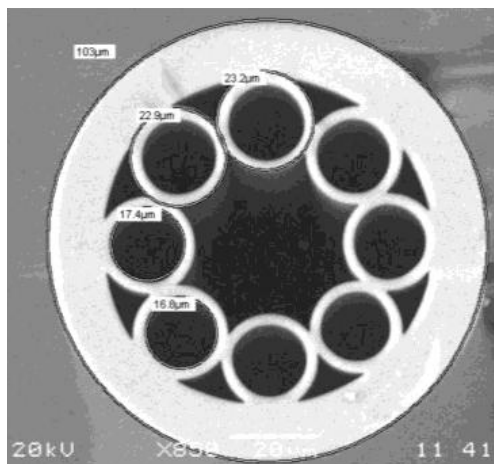
Benabid et al., *Science* **298**, p. 399, (2002)



Debord et al., *Opt. Lett.* **39** (21), p. 6245, (2014)

Kagomé fibre

- Higher loss
(~0.1-1 dB/m typical)
- ~1000 nm transmission window



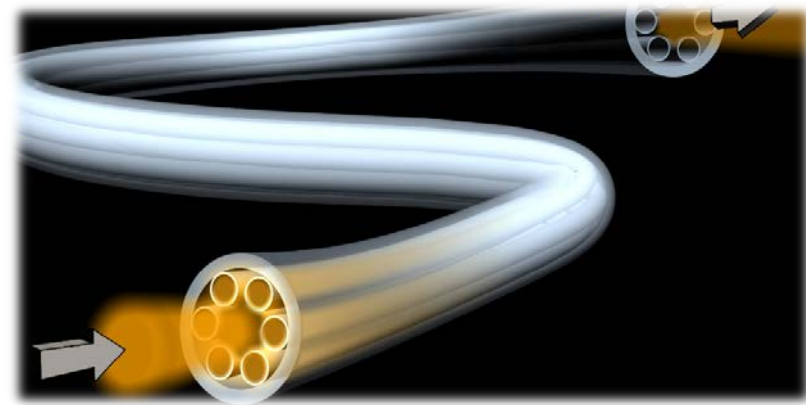
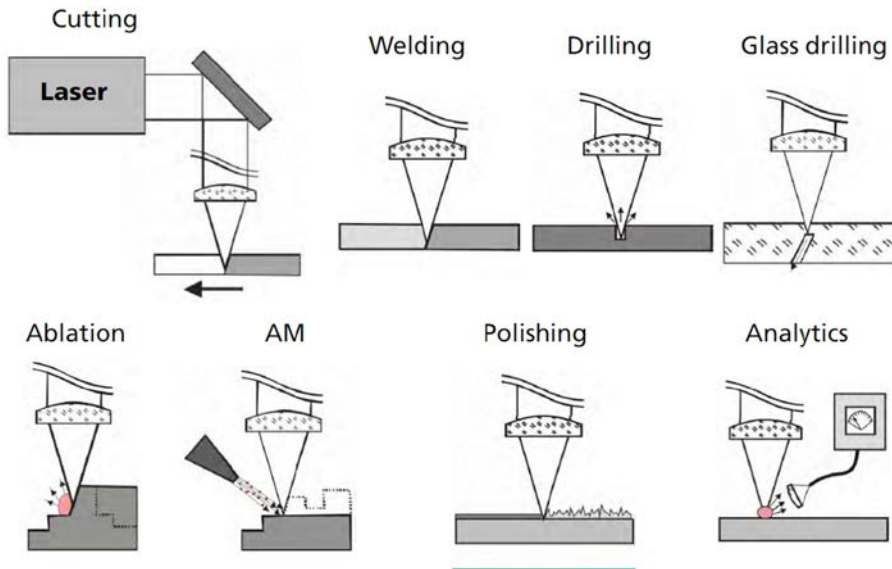
Pryamikov et al., *Opt. Express* **19** (2), p. 1441, (2011)

“Single-ring fibre”

- Ease of fabrication
- Simple structure to model
- Losses and transmission windows comparable to best kagomé fibres

New generation of hollow core fibers

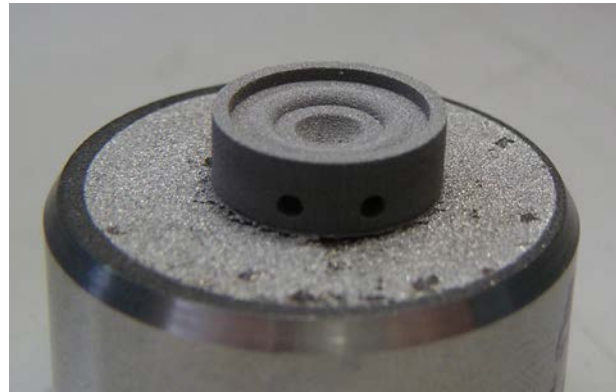
- Delivering laser radiation in a wide range of
 - wavelengths (UV - NIR)
 - pulselengths (CW - femtoseconds)
- through the same fiber.
- Using the same fiber for the diagnostic signal



Potential benefits of "smartness" in laser based manufacturing

- Self-correcting processes
- Product-adapted process parameters
- High energy effectiveness

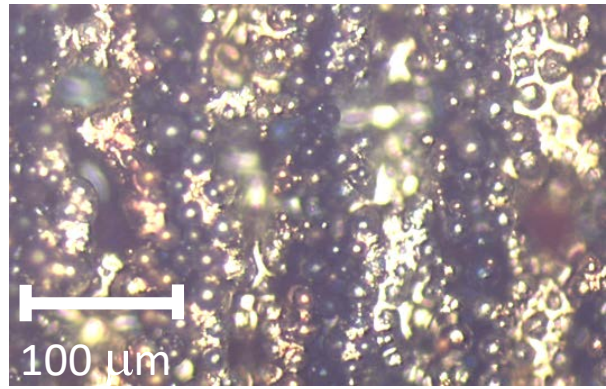
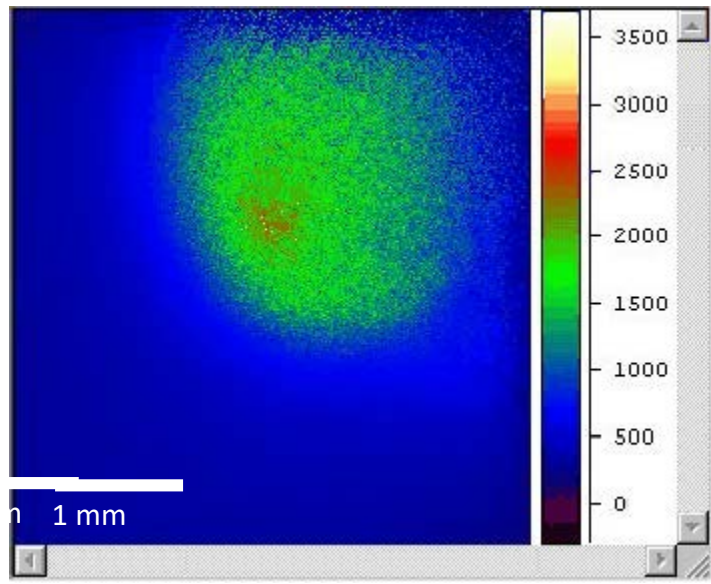
SLS part produced in a collaboration
between EPFL/IAP (Ø15mm)
Ø15mm, 200 25µm layers



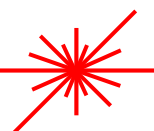
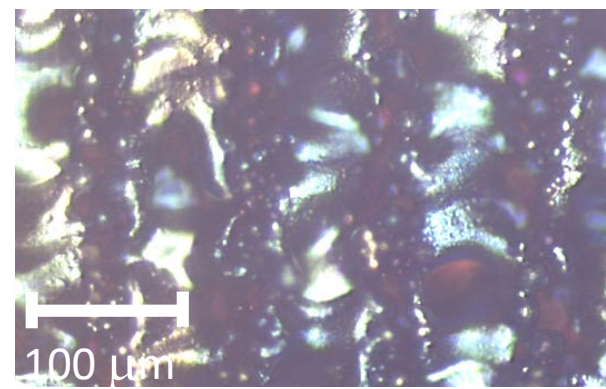
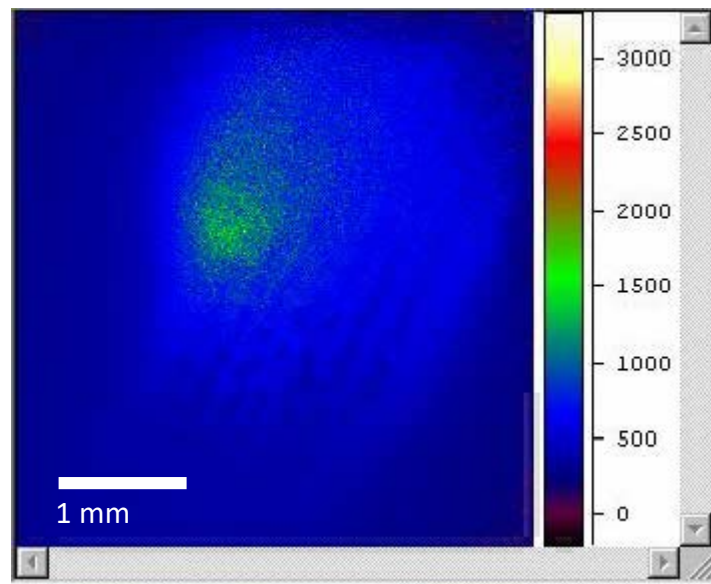
P = 1.4W,
f=2kHz, v=40mm/s

Higher quality at lower power...

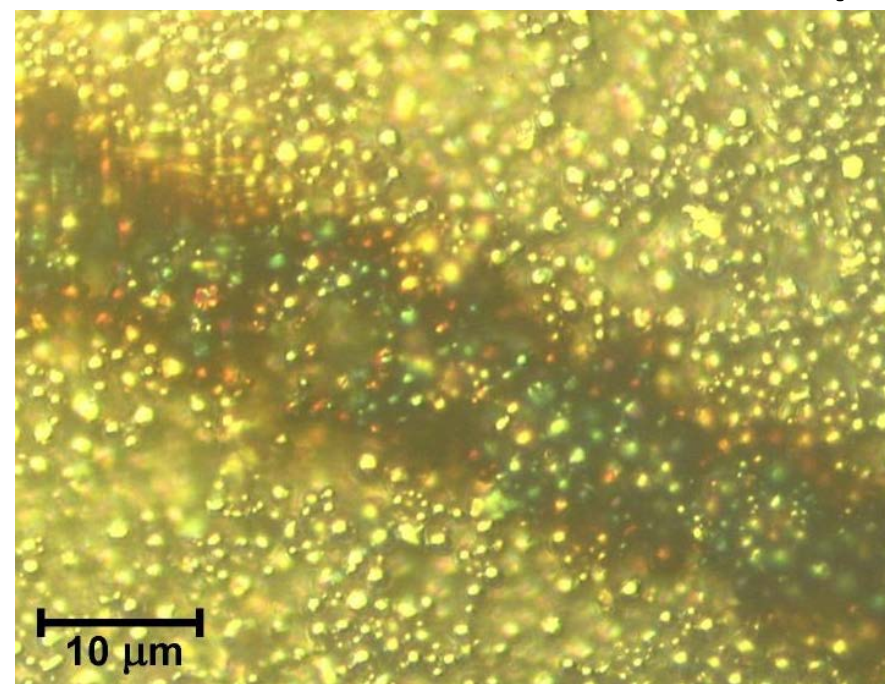
Continuous wave interaction:
3 watts average power



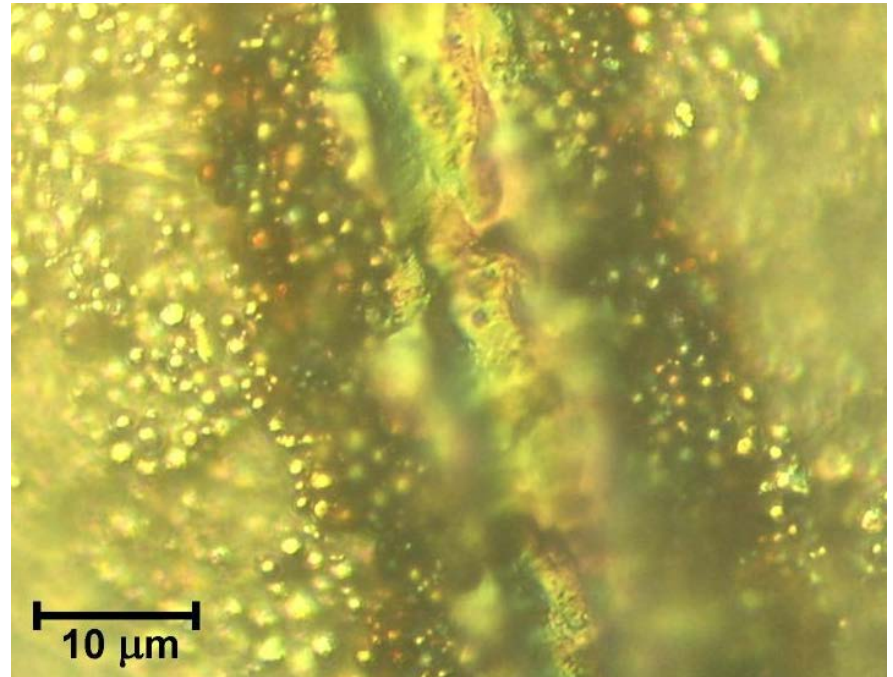
Pulsed interaction
2 watts average power



Consolidation of nanopowder with ps-pulses



Sintered with Nd:YAG,
195 mW average power (*critical*)
150 ps pulses, 80 MHz



Sintered with Nd:YAG,
275 mW average power
150 ps pulses, 80 MHz

Summary

- In connection with laser based manufacturing "smart" means not only optimizing processes themselves but also continuously monitoring them and generating feedback in real-time
- Photonics offers a wide range of tools to do that and in connection with digital data methods it can do it intelligently.
- Fast transmission and processing of BIG amounts of digital data is necessary to implement "smartness"

Thank you for your attention