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# Additive Manufacturing of Ceramics

## Opportunities and Challenges

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Nancy | 9.6.2016



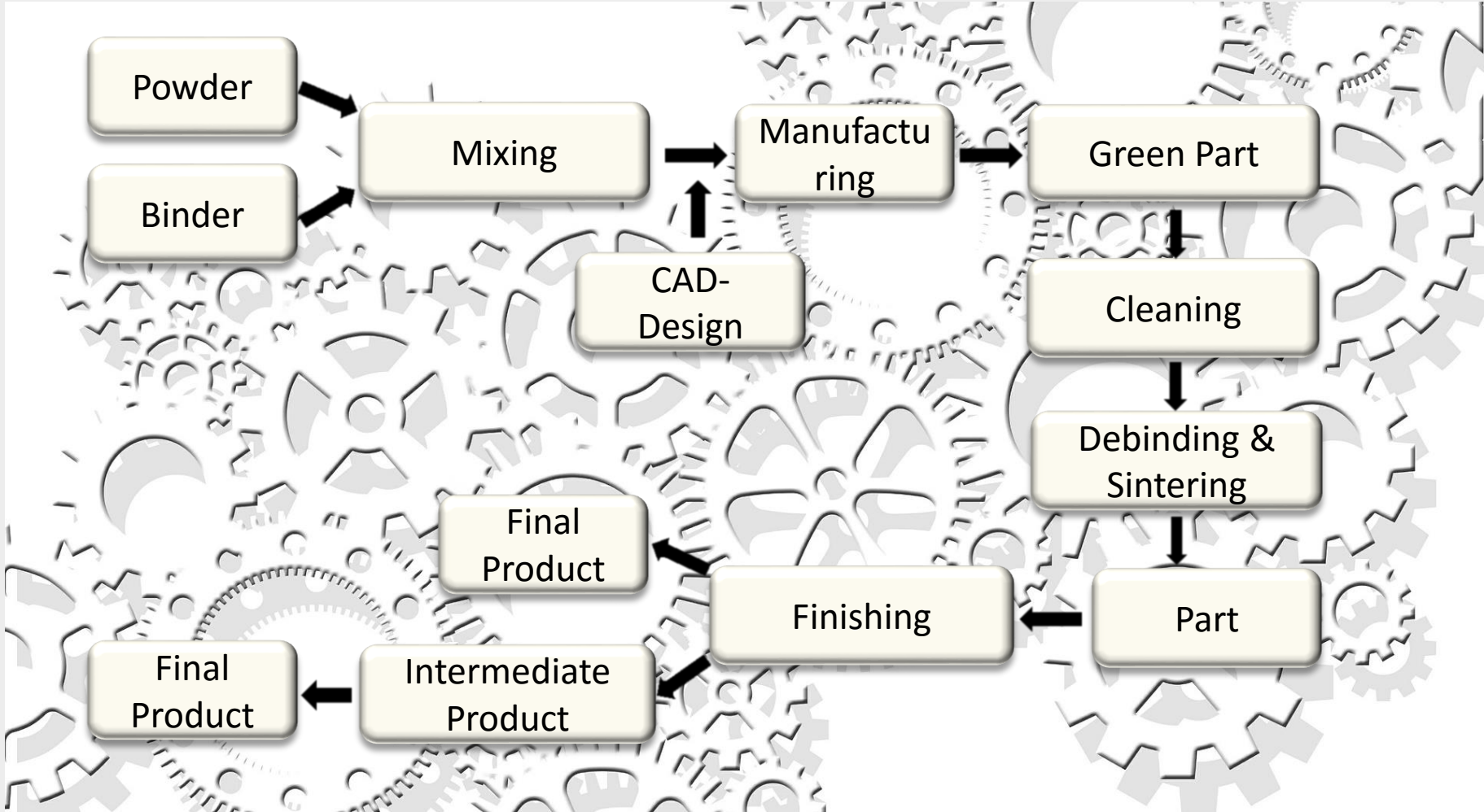
# Market for Ceramic AM

Company	Process	Material	Machines sold
Lithoz	LCM-Technology	Slurry	> 25
Prodways	Moving DLP	Paste	1-3
3D Ceram	Stereolithographie	Paste	1-3
Schunk	Binder-Jetting	Powder, Only RBSiC	Only service provider

## Additive Manufacturing of Ceramics

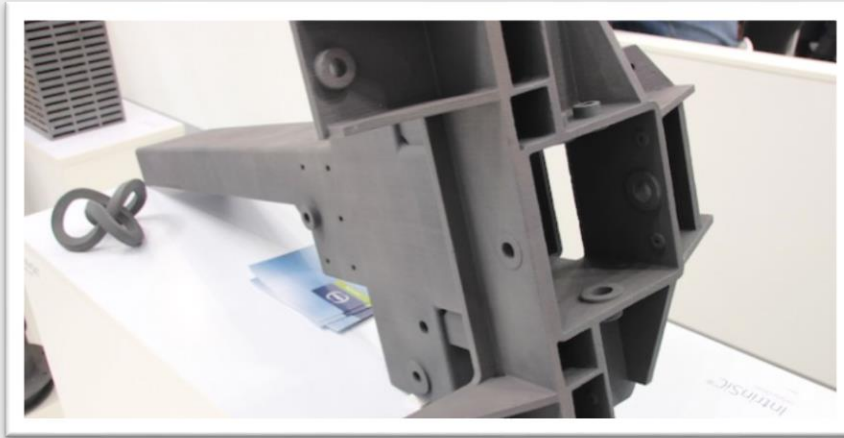
- Available materials are limited
- Processes are complex
- Whole process chain needs to be considered
- Market is still underdeveloped
- Potential of AM is not yet fully understood
- No ceramic success stories
- Many myths around AM

# Process Chain



# Myth 1

## There is one superior AMT



*Schunk Ingenieurkeramik  
InstrinSiC - SiSiC*



*Lithoz GmbH  
LCM-Technology*

# Myth 2

## Additive manufacturing is simple

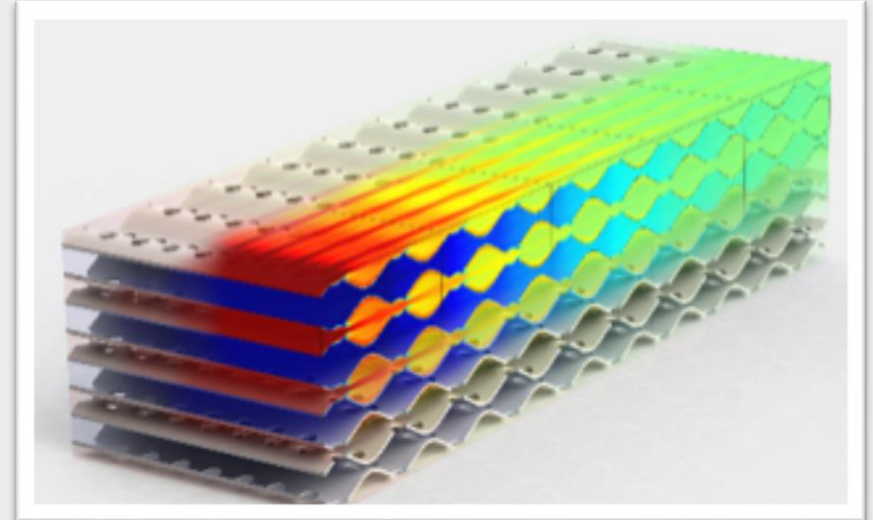
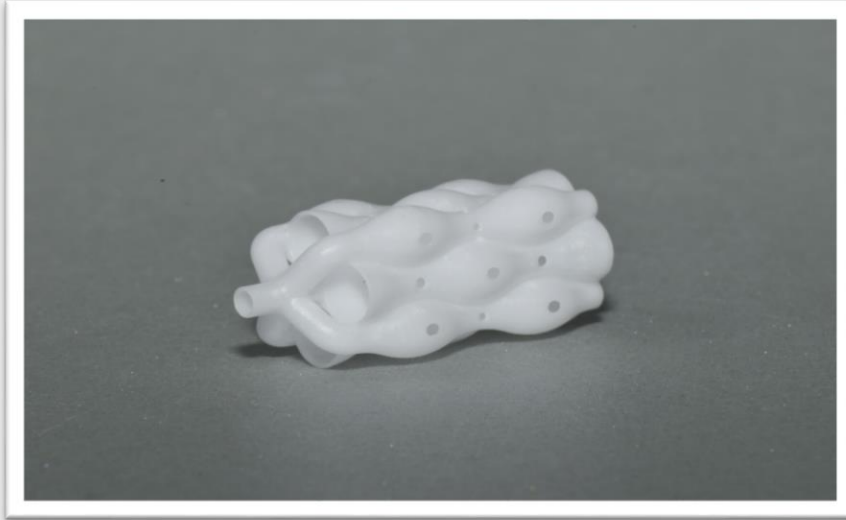


## Just hit “print” and you are done

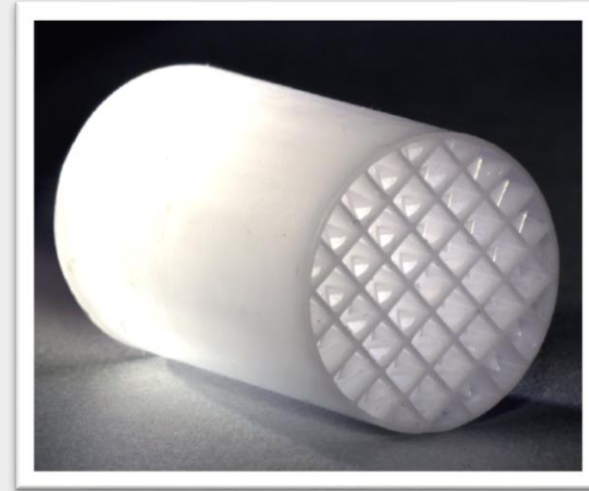
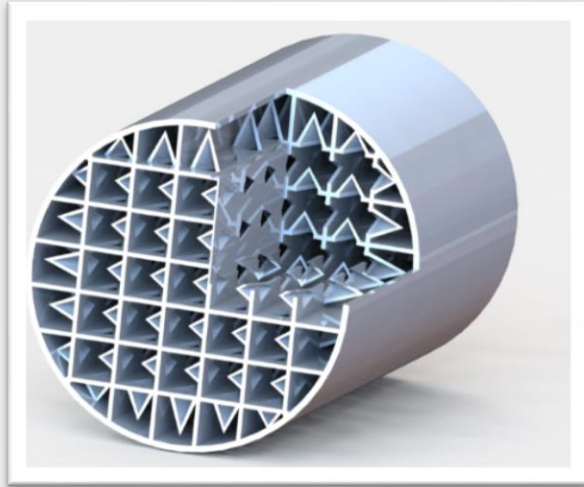
- Understanding the limitations and rules
- Designing for AM
- Choosing the right parameters
- Understand the technology and the machine
- Playing time is required
- Development of expertise is important

## Myth 3

Designing for AM is state of the art



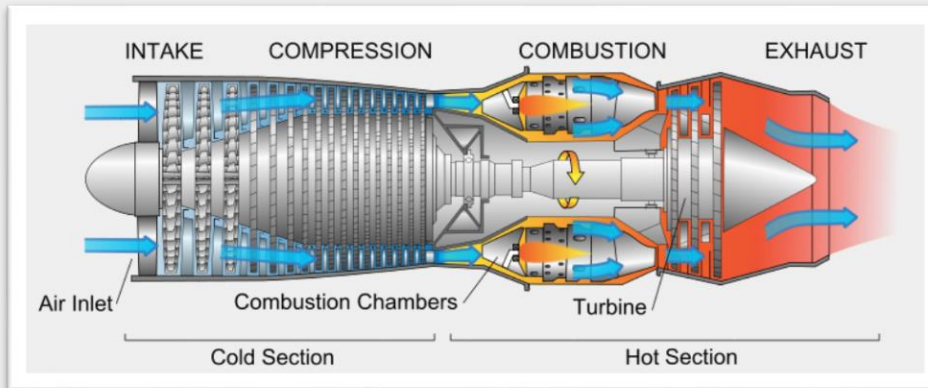
- Completely new design with varying channel cross section and interconnections
- Improved efficiency due to turbulent flow
- Shorter reaction way
- Less material for mixer



- Cut-outs and flow guiding elements (spoilers)
- Deflection of the fluid in the individual channels
- Increased wall contact
- Productivity and efficiency is increased
- Less material for carrier and catalyst

# Casting Cores

- Used for production of turbine blades
- Complicated design
- Support structures necessary



	Volume [mm <sup>3</sup> ]	Wt %
Core geometry	4868	
Support structure	61	+1%
Waste material	541	+11%



- Whole process chain has to be considered
- New designs possible (hollow structures)

	Injection Moulding	Paste AM	Slurry AM
Core geometry	Small Aerospace		
Support structure	N/A	+1%	+1%
Waste material (e.g. sprues, resin on part)	+10-20%	15%	+11%
Potential design savings (hollow features)	N/A	N/A	-10%
<b>TOTAL (additional wt% waste)</b>	<b>10-20%</b>	<b>16%</b>	<b>2-11%</b>

- AM provides new opportunities in terms of design and functionality
- Material efficiency due to better performance
- Whole process chain important to realize the full value
- Fruitful partnerships necessary
- Out-of-the-box-thinking necessary
- Freedom and the scope for development necessary

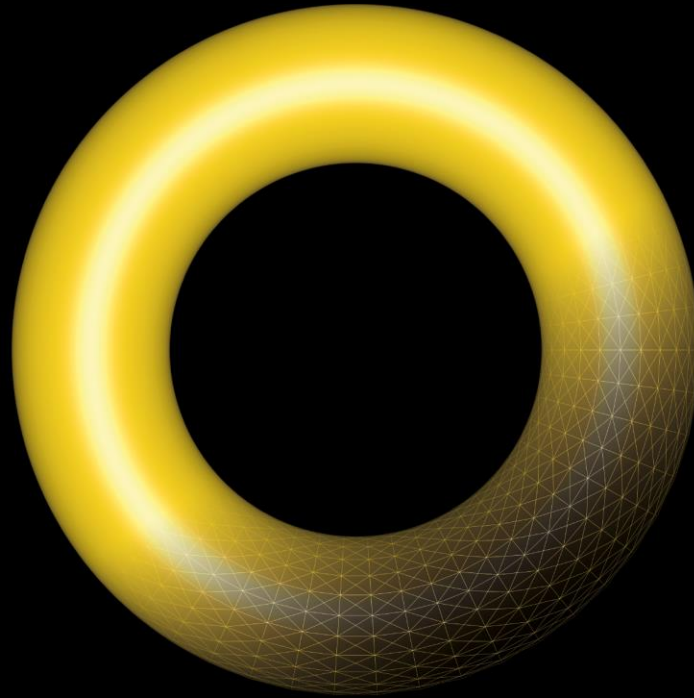
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