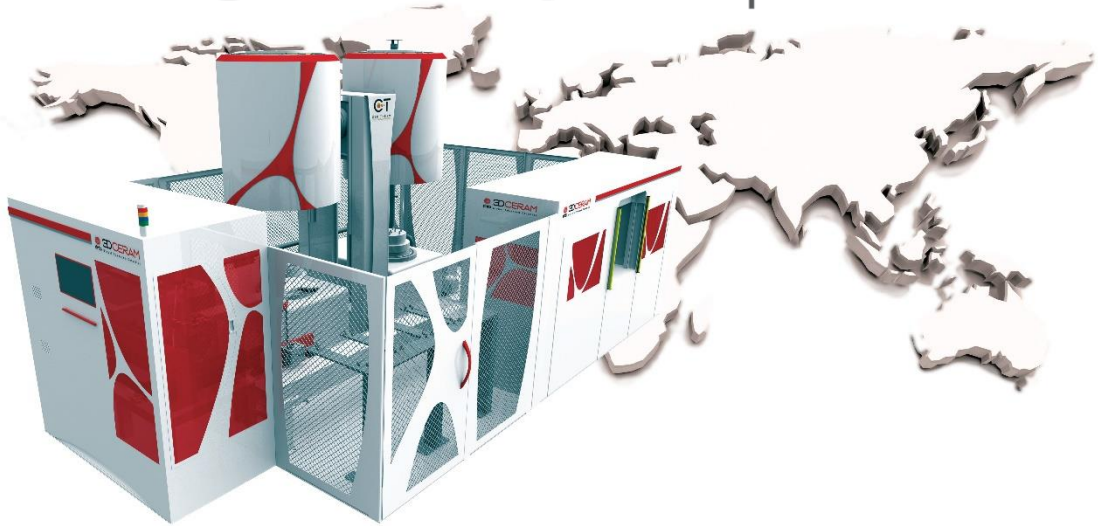
sinto

3DCERAM

SRC Spectra Research Corporation

Peter Durcan
VP of Sales

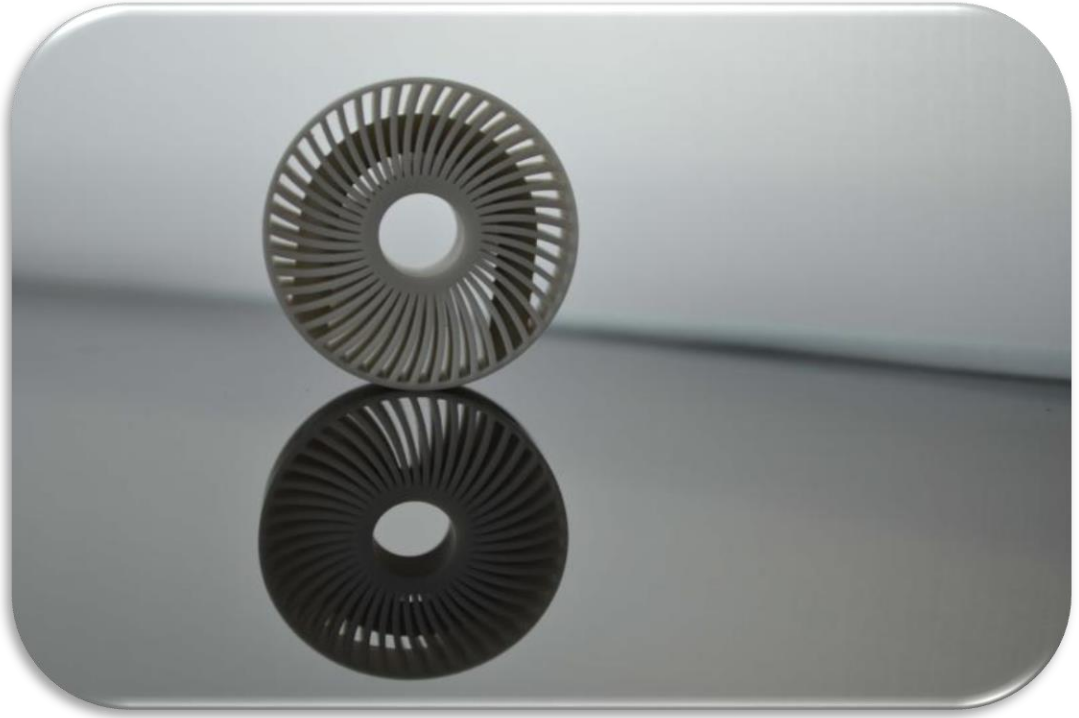
The leading ceramic additive manufacturer



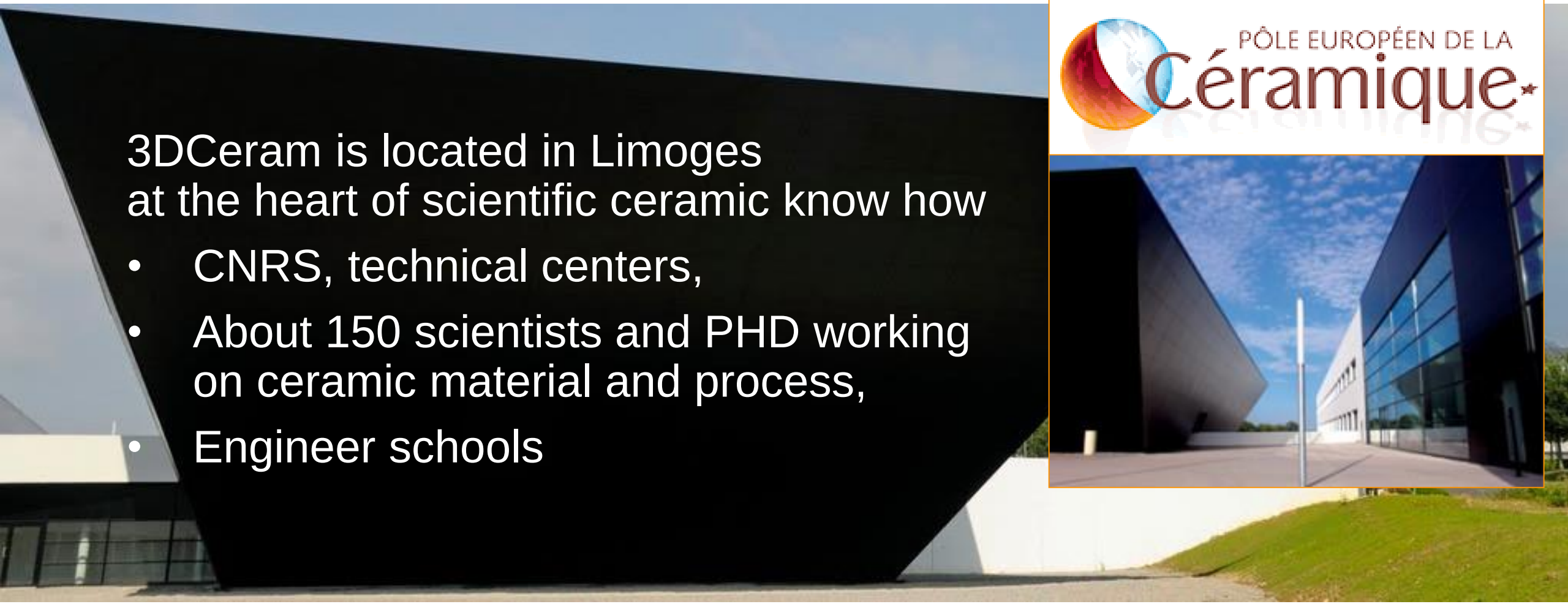
05/27/2020

AGENDA

- Introduction to 3DCERAM SINTO
- 3D ceramic printing outlook
- Machine capabilities & process work flow
- Materials currently available
- Case studies
- Summaries and Questions



BACKGROUND



3DCeram is located in Limoges
at the heart of scientific ceramic know how

- CNRS, technical centers,
- About 150 scientists and PHD working on ceramic material and process,
- Engineer schools

PÔLE EUROPÉEN DE LA Céramique

3DCERAM – SINTO

3DCERAM provides a unique user knowledge and develops leading solutions for ceramic 3D printing :

Background:

- **On demand part** production since 2005 from a spin out of the Ceramic Innovation Center
- **Development** of a 3D printer in 2010
- **Commercialization** of printers in 2016
- **CERAMAKER** printing lines and associated services, Over 30 Machines sold to date.
- **3DMIX** ceramic pastes dedicated to CERAMAKER printers and on demand formulation
- **Member** of the SINTO AMERICA group since 2018
- **300+** Employees

A WORLDWIDE PRESENCE

sinto

ADDITIVE MANUFACTURING ECOSYSTEM

- 3DCERAM
- 3DCERAM Inc
- 3DCERAM China
- VCERAX Japan

USA MARKET FORECAST 0 - 10 YEARS

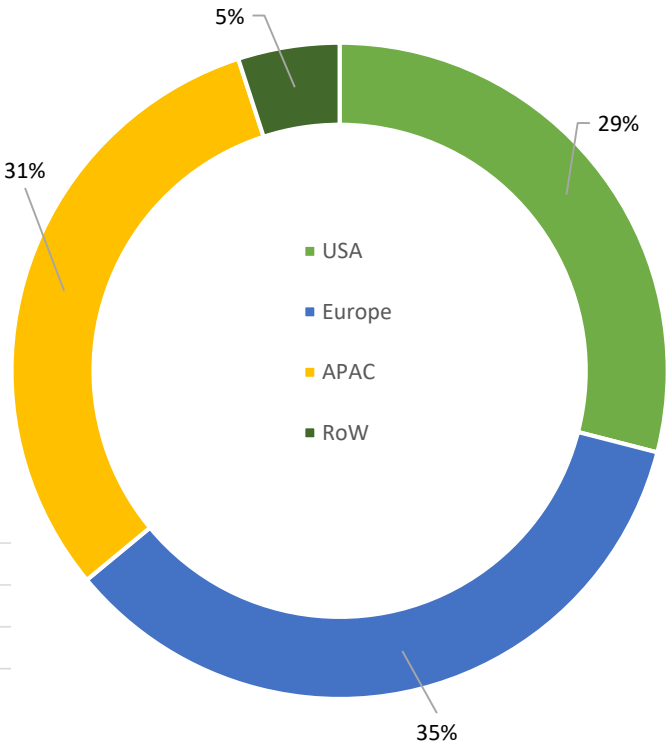
SMARTECHMARKETS PUBLISHING

❖ Spartech market research study

- Scenario 1 (S1) technology is adopted by large scale manufacturing players
- Scenario 2 (S2) continuing as a niche market, R & D centers

SLA	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	
S1	23	38	66	102	134	185	336	622	810	1038	1206	Unit
S2	31	38	44	58	67	82	96	113	135	166	201	Unit
S1	6.98	11.02	18.48	27.41	33.5	47.97	84	155.38	194.4	228.25	214.2	M$
S2	9.3	11.02	12.32	15.66	16.75	21.32	24	28.25	32.4	36.52	40.2	M$

Geographic repartition

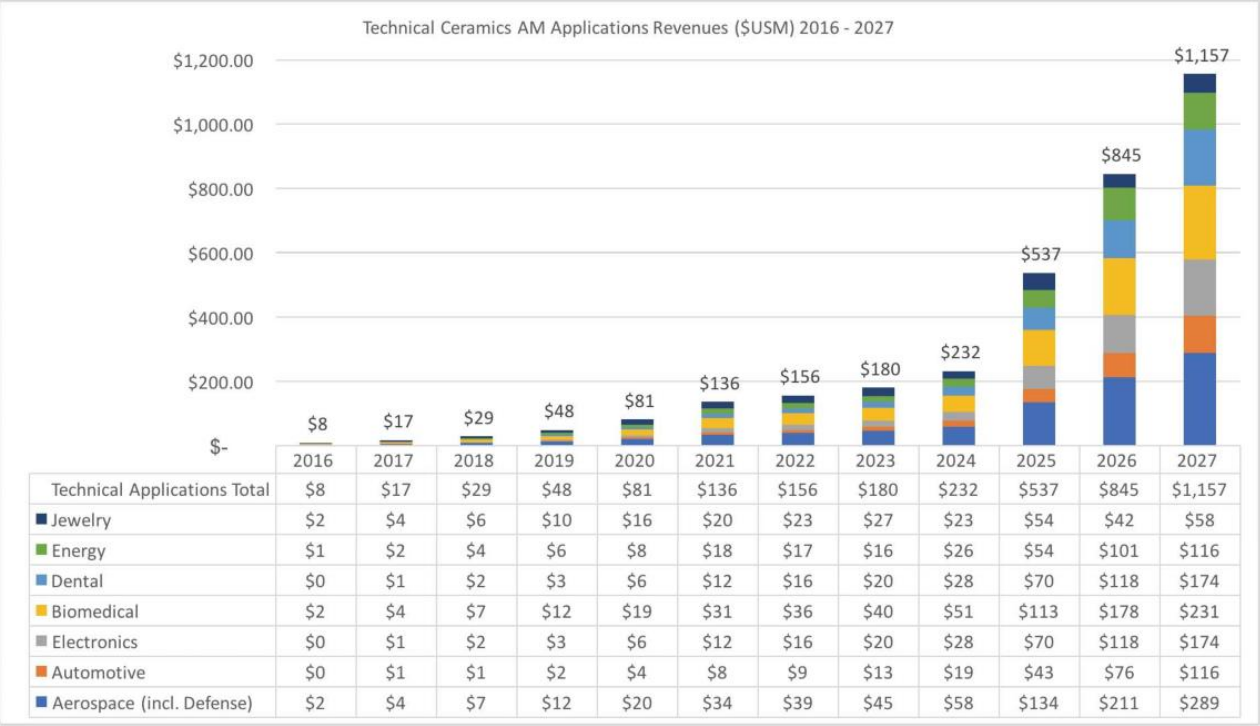


Depending on scenarios, between 40 M$ and 214 M$ SLA machine sales in 2027

TECHNICAL CERAMIC ADDITIVE MANUFACTURING MARKET

- According to the Smartech survey Market forecast by 2027 for **ceramic AM parts** will be between 56 and 1 157 million $
- Several Markets are starting to use more and more 3D parts (biomedical, space, energy…)

Exhibit 4-8a: S1 Forecast of Technical Ceramics AM Part Value

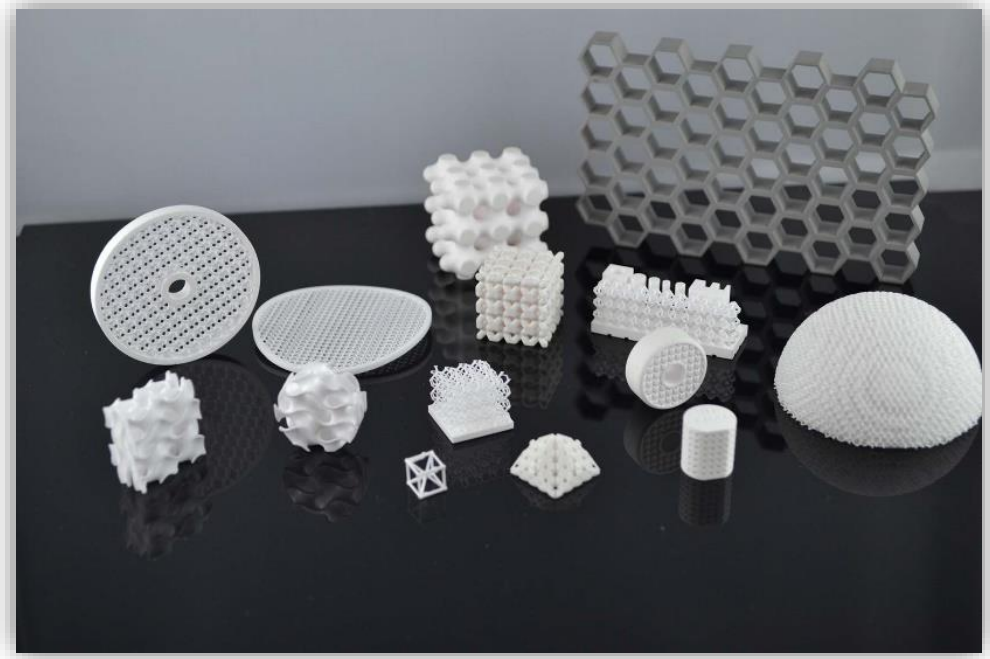


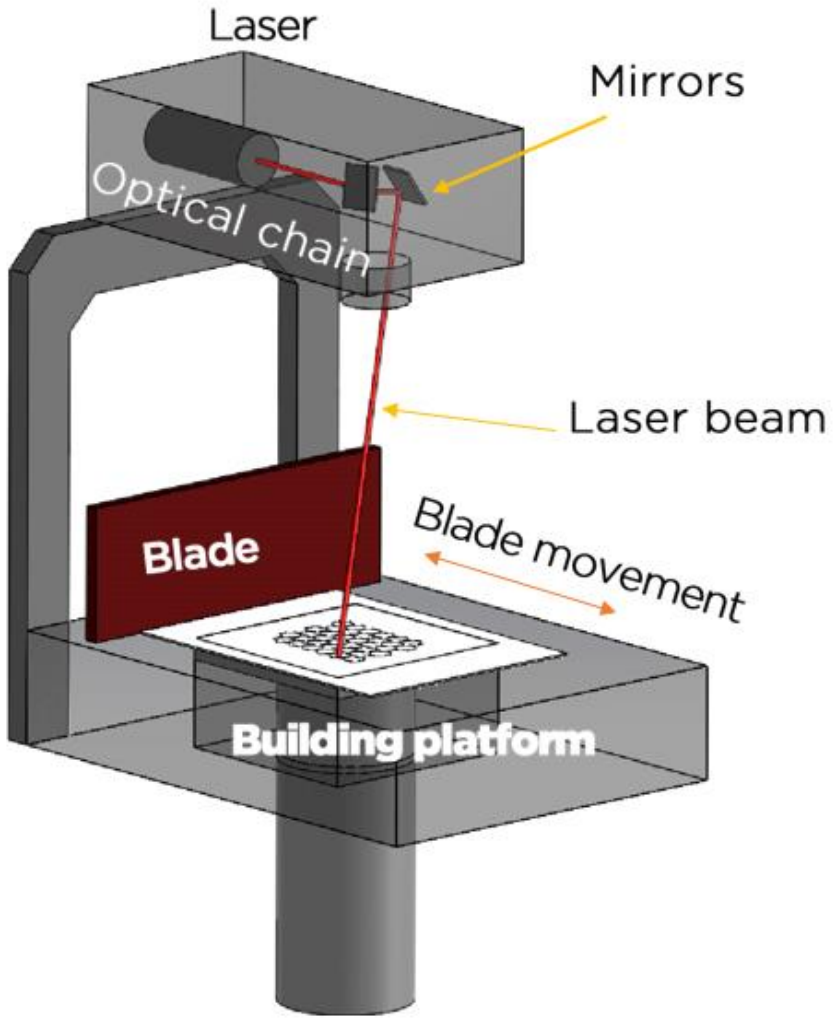
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Technical Applications Total	$8	$17	$29	$48	$81	$136	$156	$180	$232	$537	$845	$1,157
Jewelry	$2	$4	$6	$10	$16	$20	$23	$27	$23	$54	$42	$58
Energy	$1	$2	$4	$6	$8	$18	$17	$16	$26	$54	$101	$116
Dental	$0	$1	$2	$3	$6	$12	$16	$20	$28	$70	$118	$174
Biomedical	$2	$4	$7	$12	$19	$31	$36	$40	$51	$113	$178	$231
Electronics	$0	$1	$2	$3	$6	$12	$16	$20	$28	$70	$118	$174
Automotive	$0	$1	$1	$2	$4	$8	$9	$13	$19	$43	$76	$116
Aerospace (incl. Defense)	$2	$4	$7	$12	$20	$34	$39	$45	$58	$134	$211	$289

GLOBAL SOLUTIONS FOR CERAMIC 3D PRINTING

3DCERAM supplies complete **turnkey solutions** for technical ceramic 3D printing

- **Complete line** (Ceramaker, kilns,…)
- Ceramic **3DMIX** for Ceramaker machines
- **Services** (training, on demand part printing)

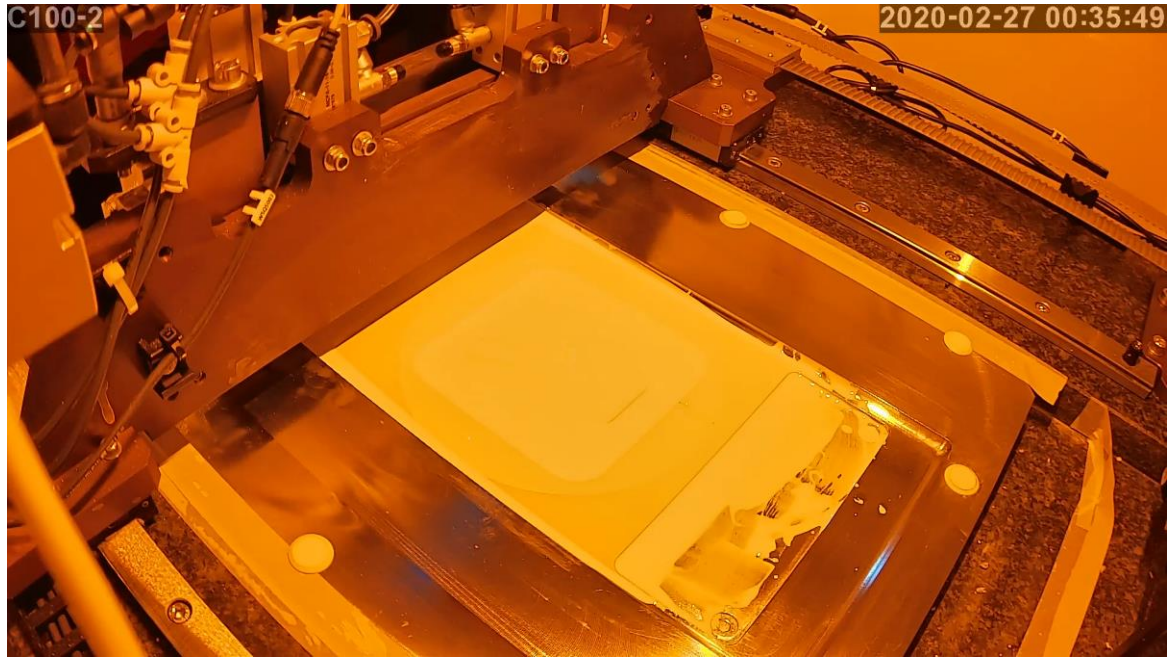




Stereolithography (SLA)
applied to advanced ceramics

SLA PROCESS: 4 STEPS

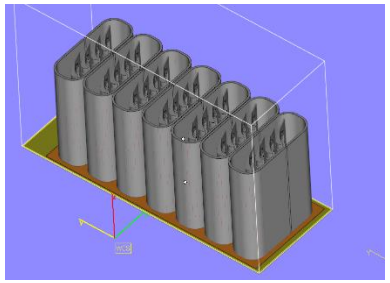
- Preprocess:
  - Creation of the CAD
  - Export to STL file and slicing
- Printing layer by layer.



1

PREPROCESSING

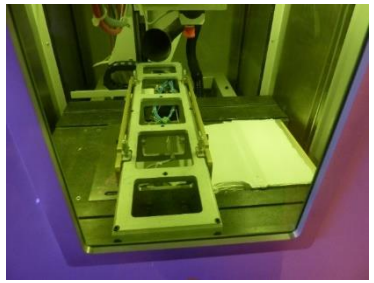
CAD file preparation

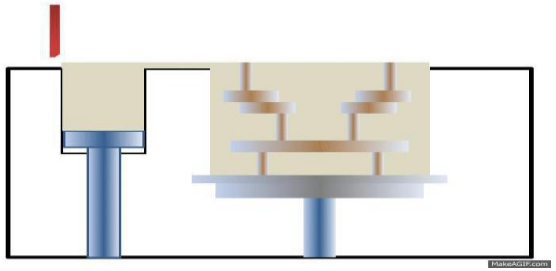


2

3DPRINT

Printing of a batch parts





POST PROCESS

- Cleaning
  - Removing and recovering of non polymerized paste (up to 30%)
  - Removing of polymerized paste in the cleaning station with compressed air and solvent.

- Firing
  - Debinding 96H
  - Sintering 24H (Shrinkage)

3

CLEANING

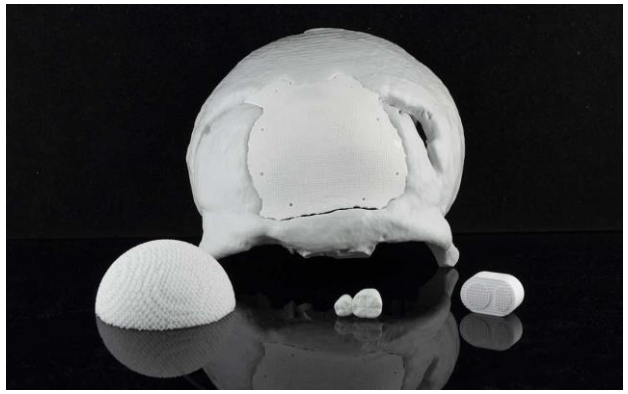
Cleaning with compressed air & solvent

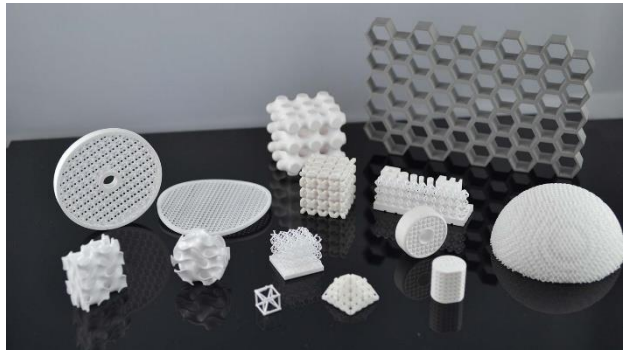
4

FIRING

Debinding & sintering


3DCERAM®
A range of 3D printers for ceramics
C100-EASY
C900-FLEX
C3600-ULTIMATE
C100EASY
For labs &
research centers
C900 FLEX
From lab to fab
C3600 ULTIMATE
For mass production





C900 : FLEXIBILITY TO EXPERIMENT AND PRODUCE PARTS

C900 FLEX

3 sizes of building platform:

100*300 mm

200*300 mm

300*300 mm

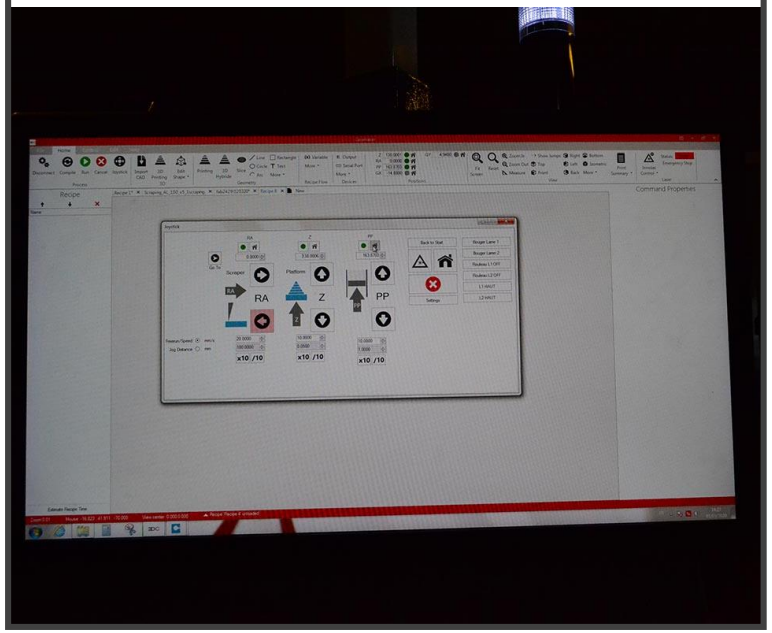
A range of 12 technical ceramics: Alumina, Zirconia, Cordierite, AlN, Si3N4, et…

3DMIX BY 3DCERAM

STANDARD

ON-DEMAND

OPEN PARAMETERS



CERAMIC MATERIALS

Structural

Silicore

Alumina toughened zirconia

Cordierite

Zirconia 8Y

Fused silica

Zirconia 3Y

Alumina

Silicon Nitride

Aluminium Nitride

Bio-ceramics

Hydroxyapatite (HAP)

Tricalcium Phosphate (TCP)

Zirconia toughned Alumina (ZTA)

WHICH MATERIAL?

- What application?
- Bone integration, tooling, device
- Hard wearing, insulator
- Thermal properties
- Price sensitive
- Material capabilities (Thickness)

- Currently developing a specific **ZTA** to be used as a potential implantable material on the 3D printer
- 3DC are sourcing the raw material that can be compatible with FDA approval

- Mechanical properties of 3DMix materials comparable to traditional manufacturing methods
- Current zirconia paste shown to meet minimum requirements for medical-grade zirconia (Jessica Schiltz, University of Notre Dame)

MARKETS & MATERIALS

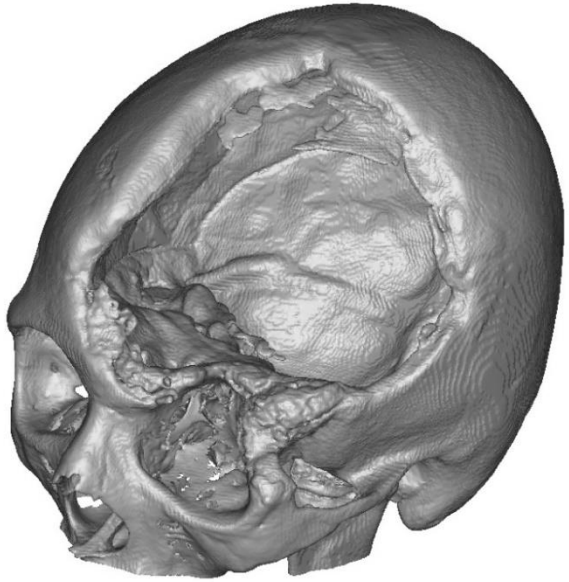
Aerospace → AlN & Si_3N_4

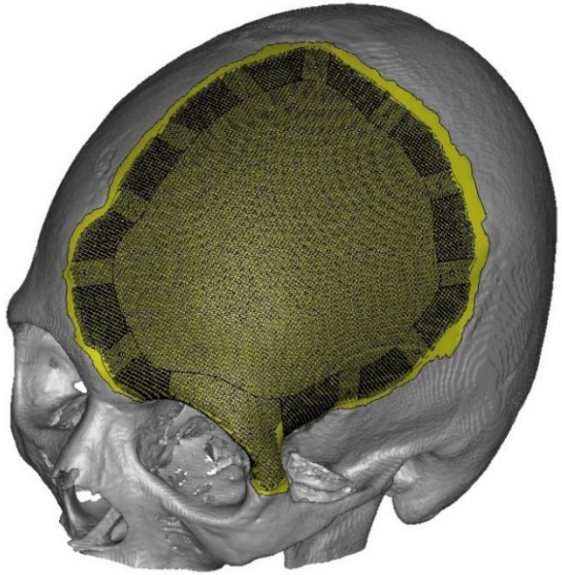
Industry → Alumina & Zirconia

Biomedical → HAP & TCP

BIOMEDICAL CASE STUDY: SKULL IMPLANTS

A study conducted in partnership with CHU Limoges



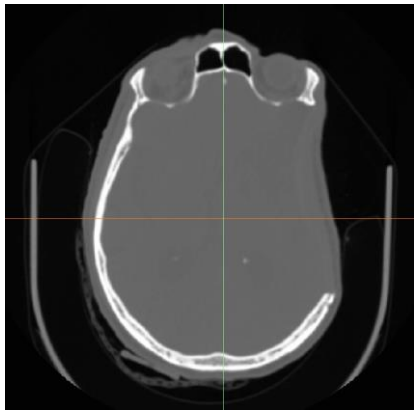


Porous and dense areas combined on the same implant

CUSTOMIZATION

EXAMPLES : IMPLANTS FOR CRANIOFACIAL SURGERY - BioCranium®

❶ **Image from hospital scanner : DICOM**

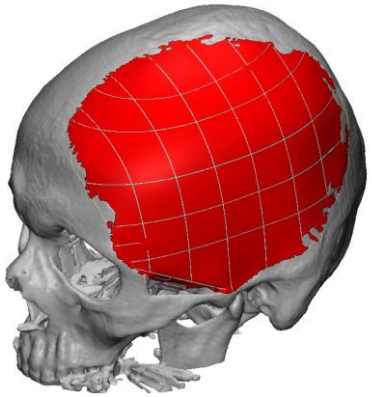


Export to STL file

❷ **Three dimensionally reconstruction**

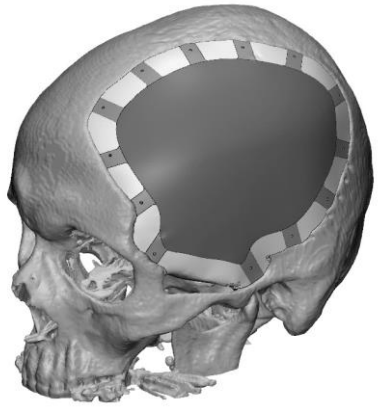
Creation of guidelines

❸ **Definition of surface and volume**



Remove undercuts Definition of fixing holes

❹ **Final CAD design of the implant in STL format**



⇒ No limitation in the implant design
⇒ All the steps are defined according to the surgeon's specifications
⇒ Strictly meets the tolerances set out in customer's specifications

UNIQUE 3D POROSITY CONTROL

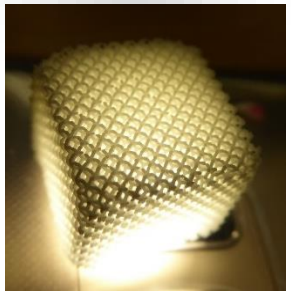
CRANIAL IMPLANT :

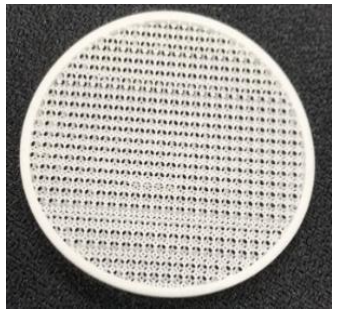
1. Porous and dense areas combined in the same implant

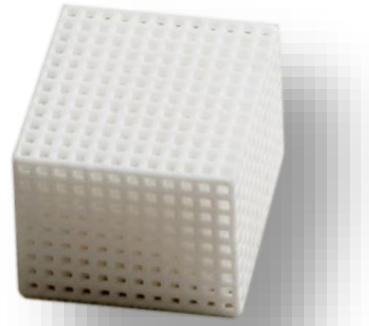
- Control the location, geometry and the diameter of pores + fixing holes in 3 dimensions

LATTICE STRUCTURE :

for bones substitutes and joint surgery
to enhance bone reconstruction

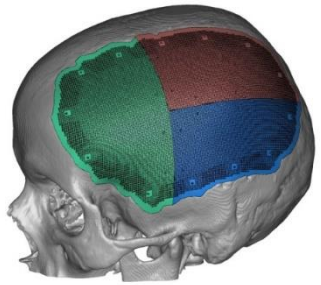


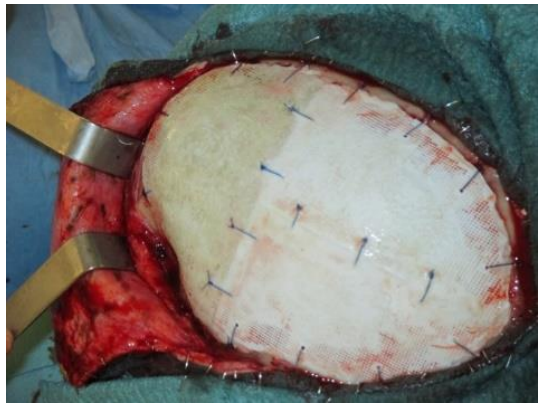




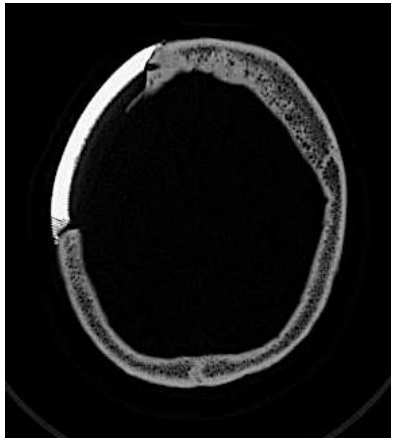
IMPLANTS FOR MAXILLO FACIAL APPLICATIONS

CLINICAL CASE :

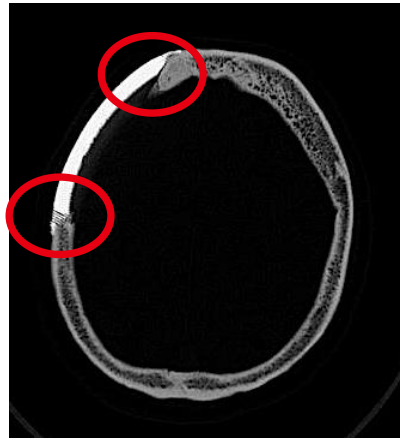




OSSEOINTEGRATION :



1 month after surgery



12 months after surgery

- **Perfect osseo integration**
- **No sign of deterioration**
- **No encapsulating membrane**
- **Total biocompatibility**
- **Good aesthetic result**
- **Low risk of rejection**

CERAMIC FOUNDRY CORES BY 3D PRINTING

1. Customer benefits:
   - Access to complex geometries
   - Reduce development time
   - Reduce cost per core
   - Reduce human resources

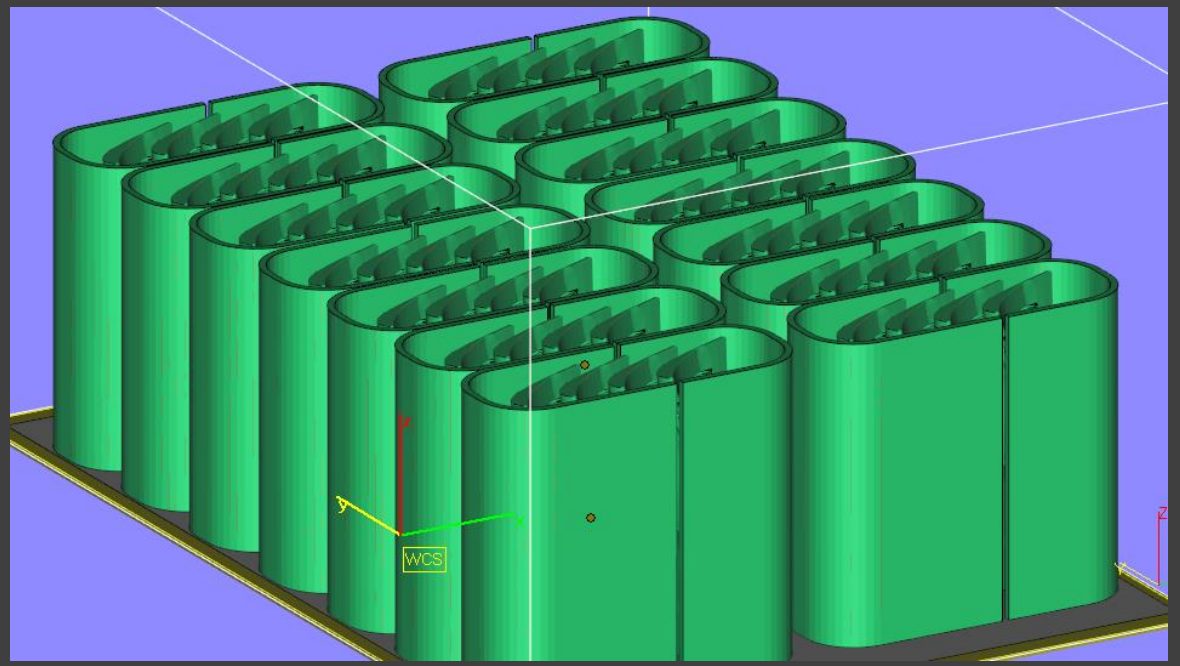
   ⇒**Increase profitability**

2. Choice of material for ceramic cores
   - Silica/Zirconia/Alumina mix
   - Alumina for hard conditions
   - Zirconia for special alloy
   - Zircon silica

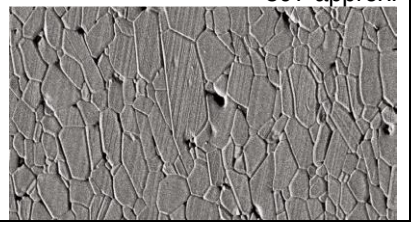
PRINTING OF CORES

Configuration 56 cores

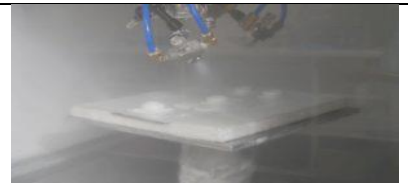
- Used at 3DCERAM to manufacture the current cores,
- 4 cores per protection support,
- Stripping support (non attached)
- **Benefits** : Maximizing the amount of cores per run on a 210mm x 210mm working platform.
- **3Dprinting time** - 56 Cores , 3Dprinting time = 150h



CONSTRUCTION REPORT

General Information	
3D Printer	CERAMAKER 900 (SLA Printer)
Material	3DMIX Alumina
Number of parts on the printing platform	56 cores
Size of the printing platform	210 mm x 210 mm
Surface quality	AS PRINTED (without any specific operation)
Size of the part (for the envelop, mm)	85mm x 30 mm x 20 mm
Density of the alumina (g/cm^3)	3.9 approx.
MPa	397 approx. 

Printing Information	
Time of working in printer's software in order to generate printing platform	2 hours
Layer thickness	50 µm
Supports	Stripping support
Printing time	Approx. 150hrs per run
Shrinkage x/y/z	Approx. 15 % after sintering
Quantity of paste for the printing run	Approx 8.2 litres per run
Laser size	35 µm

Cleaning Information	
Cleaning process	 Cleaning of parts manually or semi-automatic with cleaning station, air, and solvent
Cleaning time	Approx. 20 minutes / piece

Firing Information	
Aim of debinding	To remove all the binder from the parts
Aim of sintering	Give to the parts all the required properties (mechanical, density, …)
Debinding time	96hrs
Sintering time	3DMIX sintering cycle
Type of kilns	Electric kilns 
Maximal temperature for sintering	1200°C approx.

Finishing and Control Information	
Finishing	No finishing
RMS testing Accuracy *(please note than accuracy can be improve with the number of printing runs)*	±0, 2 mm

Other Information	
Waste	Less than 10%
Down time in order to restart another alumina printing run	1 hour

SPATIAL APPLICATIONS

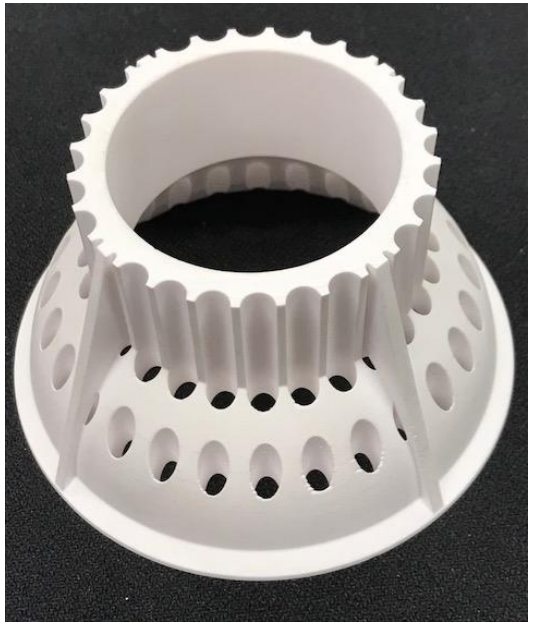
Traditionnal Space

- **Top/Down approach** : From the National interests to Space project
- **Satellite mass** > 1000kg
- **Application** : Earth **observation** / Communication / Scientific mission
- **Space Vehicule :** Big Rockets like ARIANE5 or FALCON9
- 100 launch per year and about 150 satellites

NewSpace

- **Network approach** : Some new commercial LEO application
- **Satellite mass** < 500kg
- **Application** : Change monitoring / Communication / Scientific mission
- **Space Vehicule :** Small private lancher like SpaceX or Rocket Lab
- Forecast : 2600 launch over the next 5 years for satellite constellation

EXAMPLE OF PIECES FOR NEW SPACE

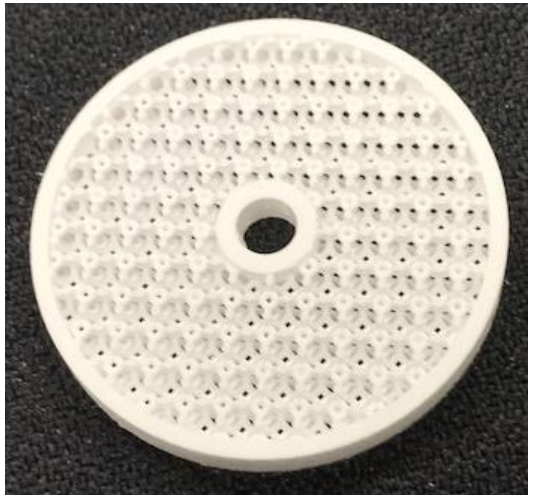


Ceramic material in NewSpace

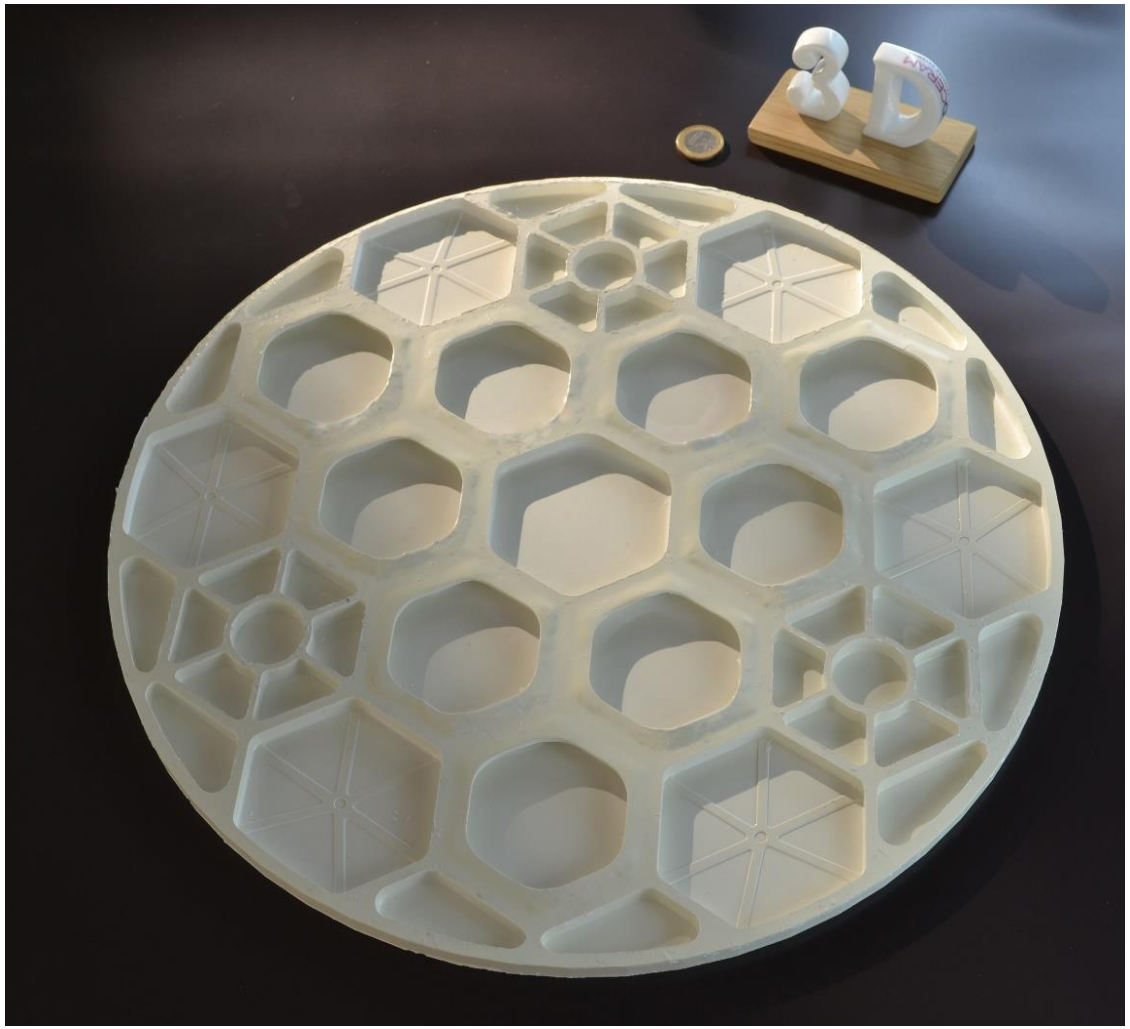
- Small vehicle = small payload = small ceramic part
- Thermal management is more tricky in small satellite => Ceramic material is a mandatory to obtain the performances
- Large range of applied ceramic like Alumina, Zirconia, Silicon Nitride

Applications

- Thrusters devices
- Heat insulator
- Optical mirror
- Full ceramic optical instrument



500 MM OPTICAL MIRROR



SUMMARY AND QUESTIONS

- Additive in ceramics is growing, early adopters are key
- Currently printing low volume batch parts in CT
- Design for printing is imperative for ceramics
- Firing cycle is the important/complicated step
- 3D printing will not replace existing technology

Questions?

Thank You

Peter DURCAN

VP of Sales

peter.durcan@3dceram.com

Serge Dandache

Directeur Général / General Manager - Spectra Research Corporation

serged@aca.ca