Dental Process Chain

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LabDay Chicago

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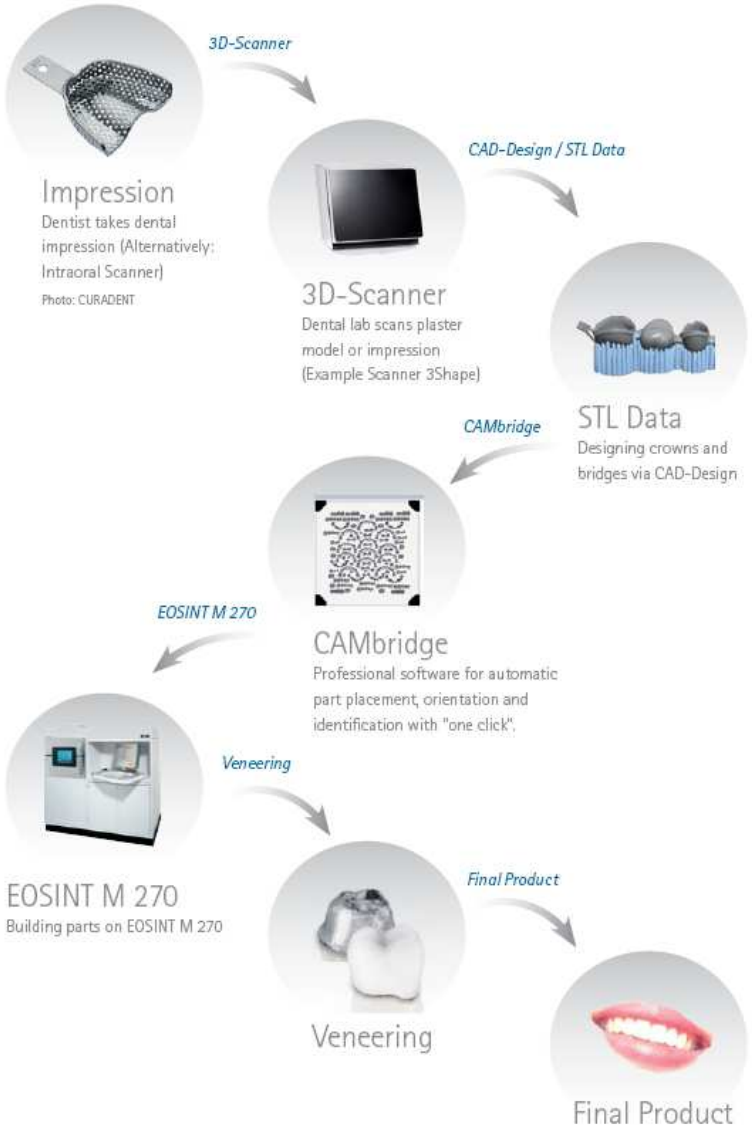
Dental Process Chain

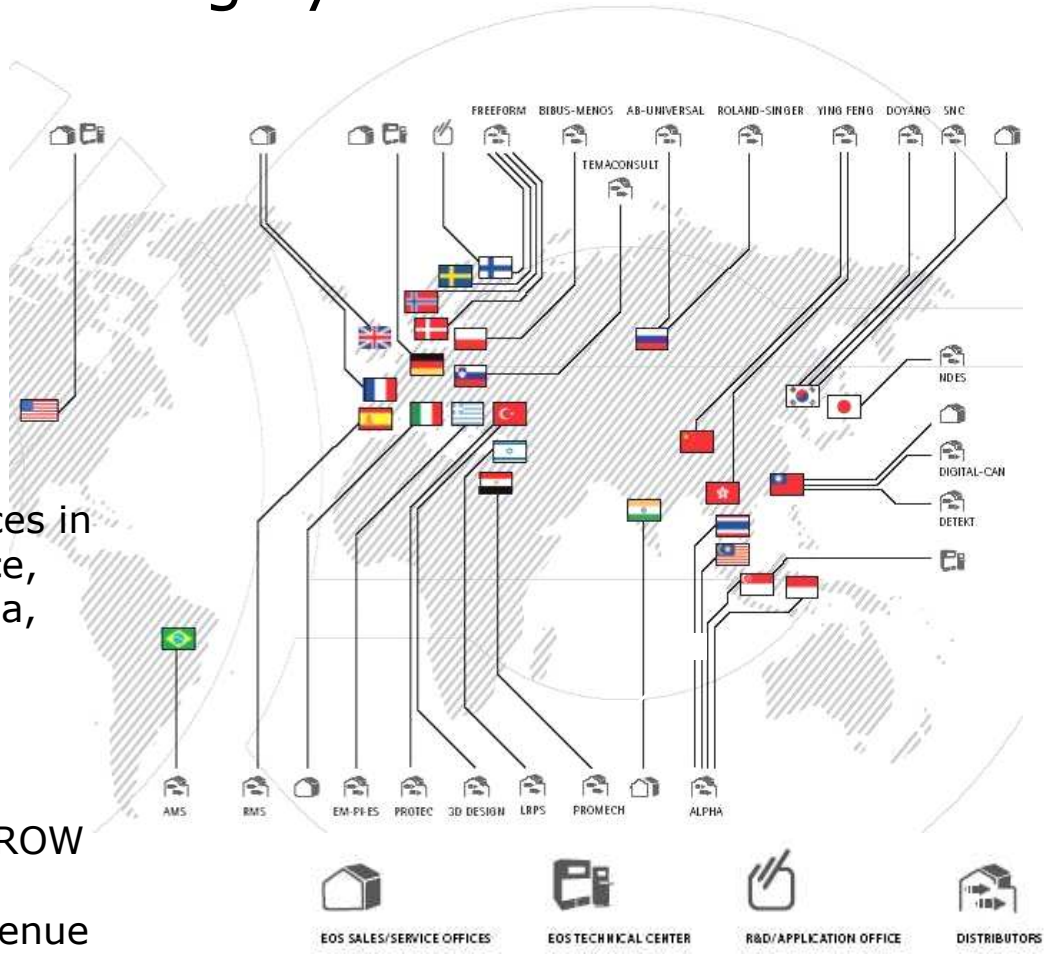
- **Overview EOS – Layer technology**
- Dental Scanning/Design
- Data Preparation
- Part Building
- Postprocessing/Veneering
- Customer Cases/Future Applications
- Quality Assurance



EOS was founded in 1989 - worldwide market leader since 2002 for laser-sintering systems

EOS worldwide 2010

- Worldwide recognized technology leader for high-end systems for e-Manufacturing™
- Customers in > 30 countries
- EOS sales/service/application offices in 10 countries (Germany, UK, France, Italy, USA, India, Singapore, Korea, Taiwan, Finland)
- Distributors in 22 countries
  - 7 distributors in Asia/Pacific
  - 12 distributors in Europe and ROW
- 350 employees and 80 Mio. € Revenue in FY 2009/2010



Source: EOS

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Customers from various industries all over the world rely on EOS technologies

Sample EOS customers (incomplete)

Source: EOS

The Medical Market for EOS

e-Manufacturing Solutions

Dental Market

- Copings
- Bridges
- Implants
- Instruments

Orthopedic Implant Market

- Hip, Knee
- Shoulder
- Ankle
- Spine
- Trauma

Medical Device

- Machine devices
- Instruments
- Endoscope
- etc.

Source: EOS

Layer Technology

- Additive technology: material is added only where is needed
- Nature also works adding…
- and typically does it in layers: trees, pearls, sediments, etc.
- In opposition to the centuries-old man traditional technologies that work removing chips

Source: EOS and PRODINTEC

EOS laser-sintering product line

EOSINT P 100

EOSINT P 760

EOSINT M 270

Source: EOS

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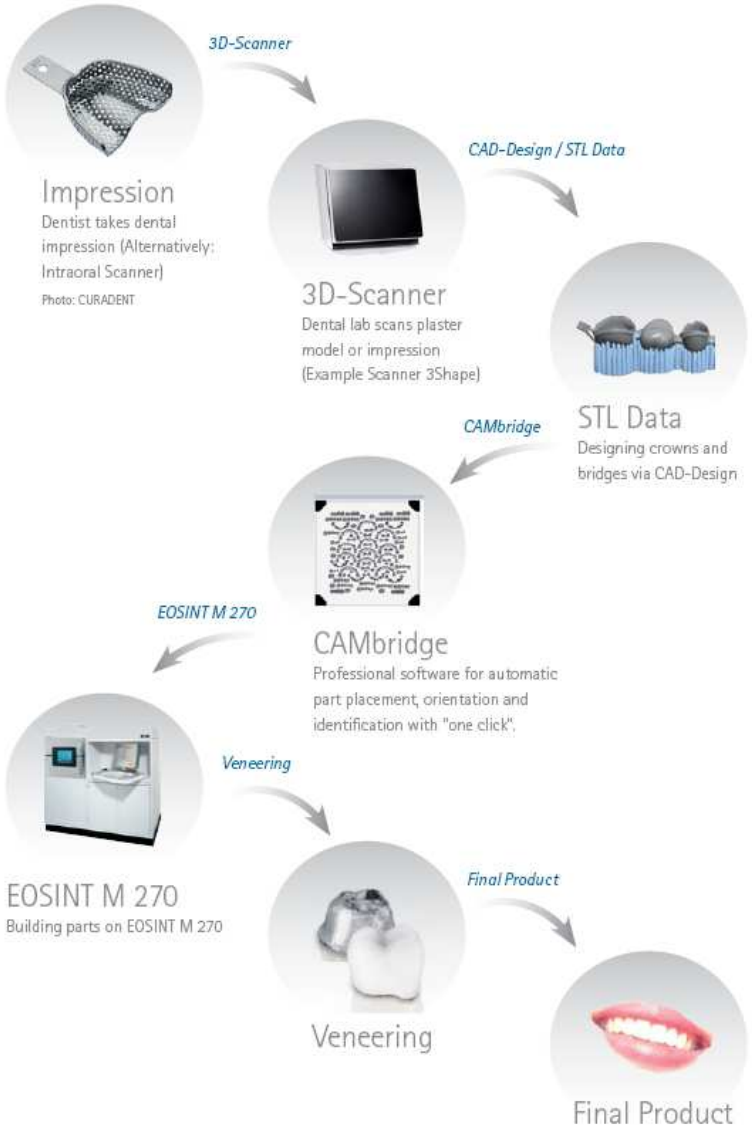


Scanning

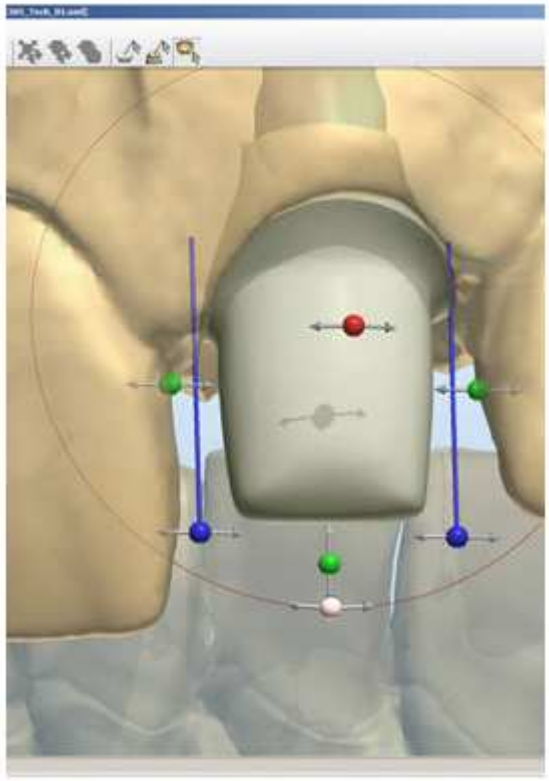
— Scanners of different suppliers like 3shape, 3MEspe, DentalWings, Optiscan can be used scanning plaster models or dental impressions.

Source: EOS

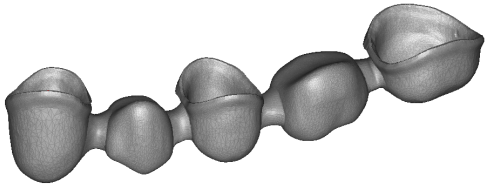
Dental CAD

- Several Dental CAD softwares are available on the market.

- Some companies offer a complete solution including scanner and software, some companies are specialized on hard- or software.



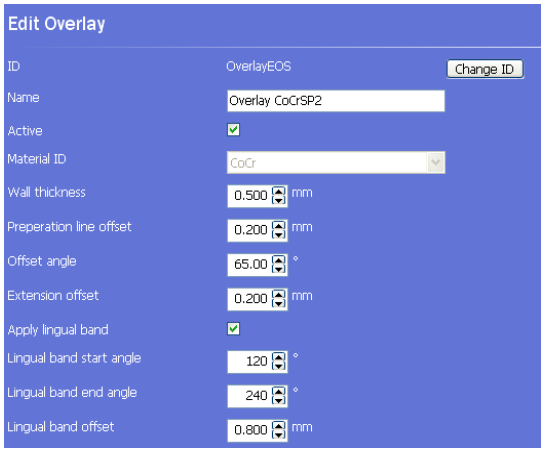
- The file format required for the dental process chain on a EOSint M270 system is STL or DCM.

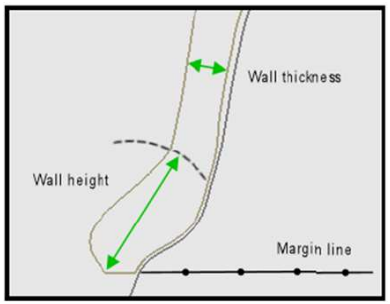


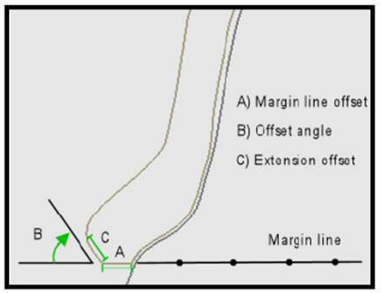
Source: EOS

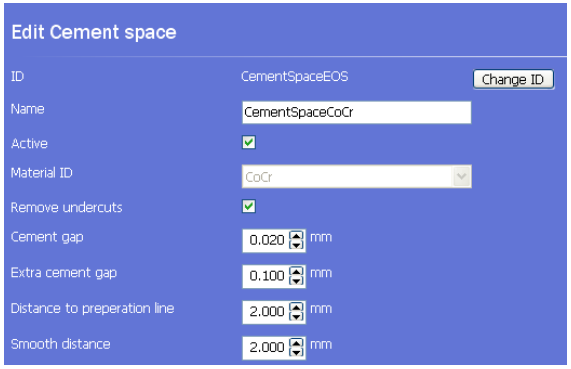
Design Rules

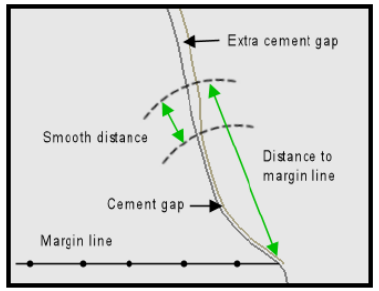
- In order to achieve good fitting dental restorations, EOS design rules are supplied.
- A wall thickness of 0,4 to 0,5 mm is recommended.
- These rules are a good starting point as the designer is able to adjust the settings according to the needs of the specific dentist.











Source: EOS

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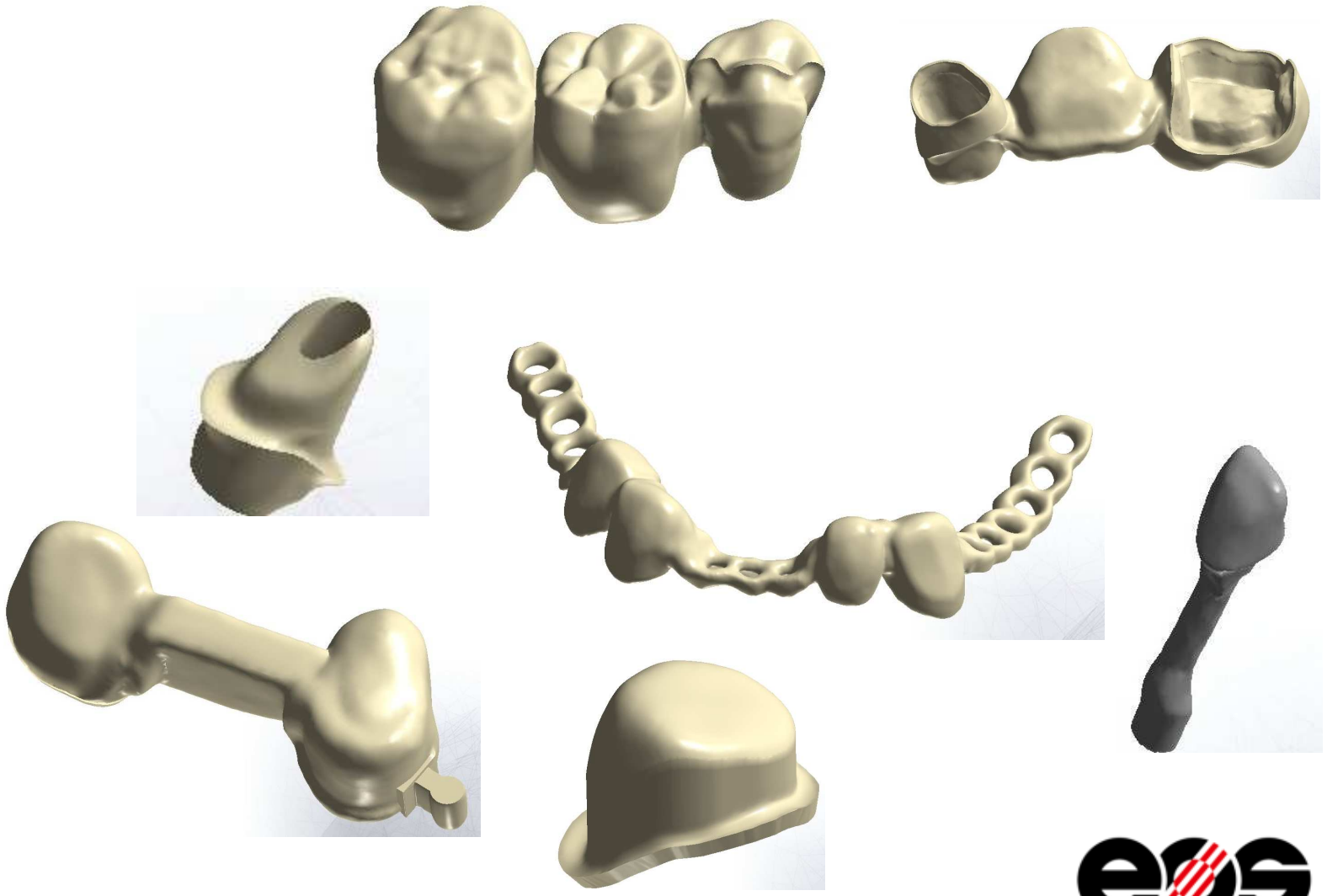
Design Options



Source: Flussfisch GmbH/D

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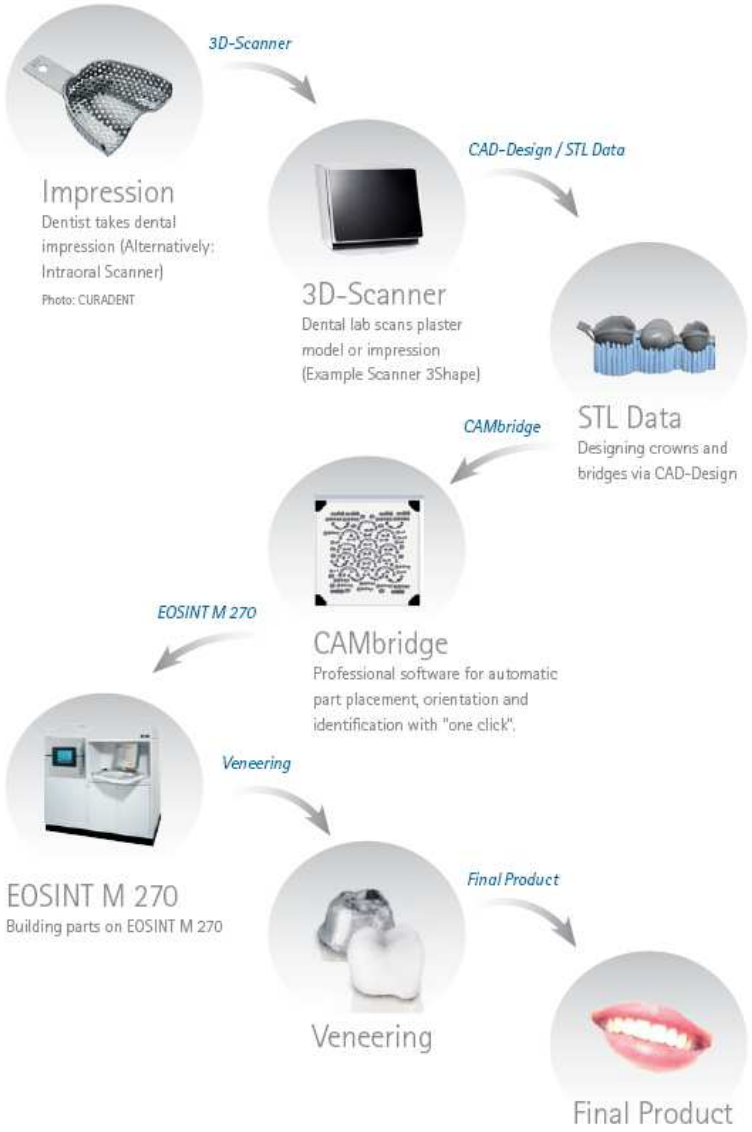
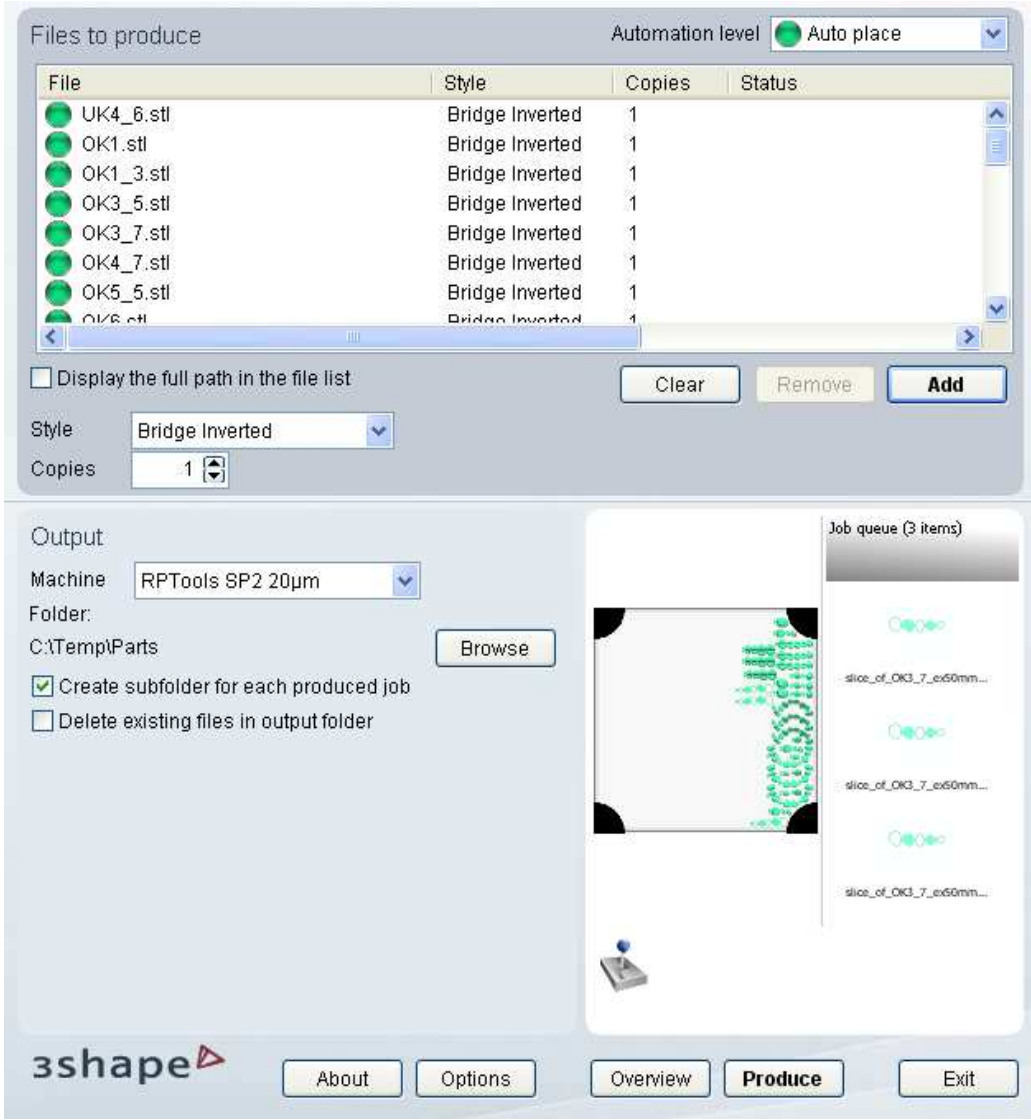


Data Preparation

- For an industrialized production of a large number of crowns an bridges, a automated software can be used.
- EOS was involved in 3shape developing "Cambridge". This software can handle up to 600 files and prepare them for the building process on the M270.



Source: EOS

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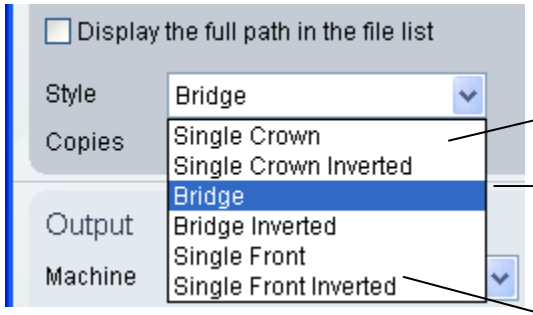
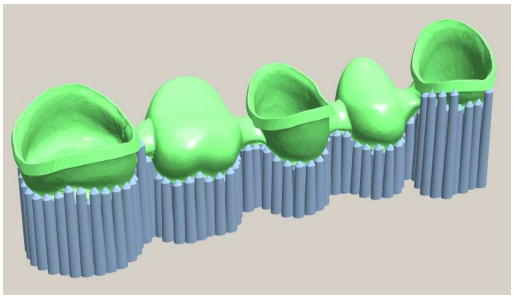
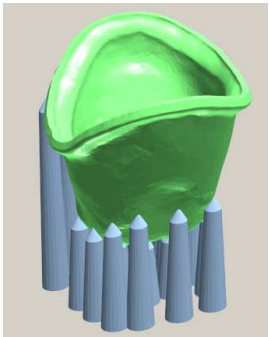
Data preparation – Support Generation

- Cambridge offers different support styles depending on the dental restauration







- The part orientation depends upon the shape of the restauration
- The number of supports depends on the support style use for the corresponding geometry

Source: EOS

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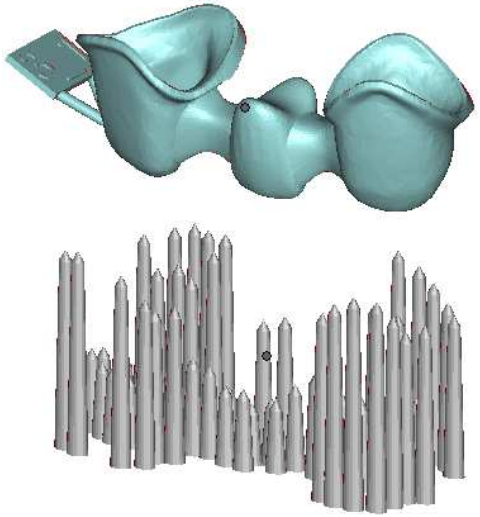
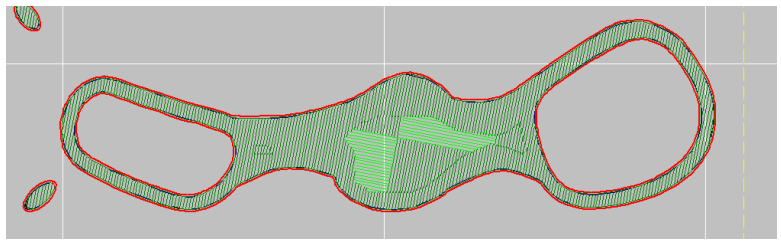
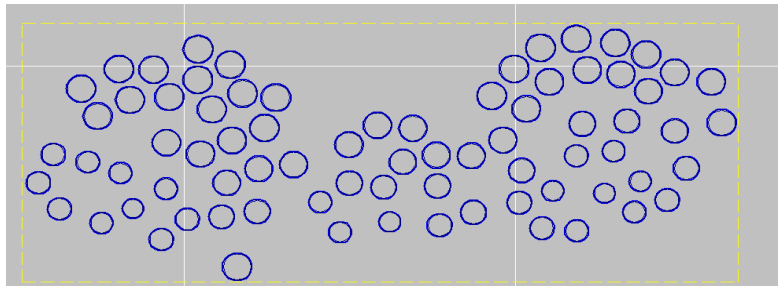
Data Preparation – File Output

- For each part processed, two files are generated
  - Part file
  - Support file
- Cambridge slices the files created in 0,02 mm layers and exports the data in SLI file format.



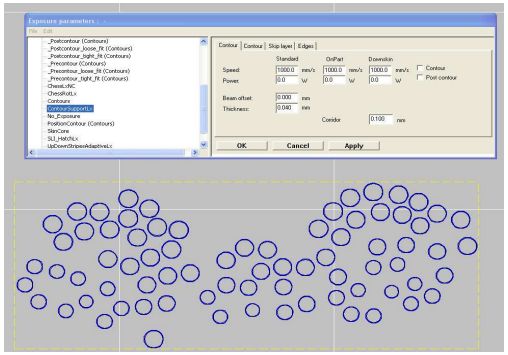


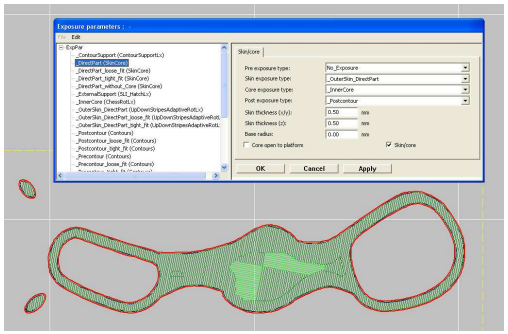


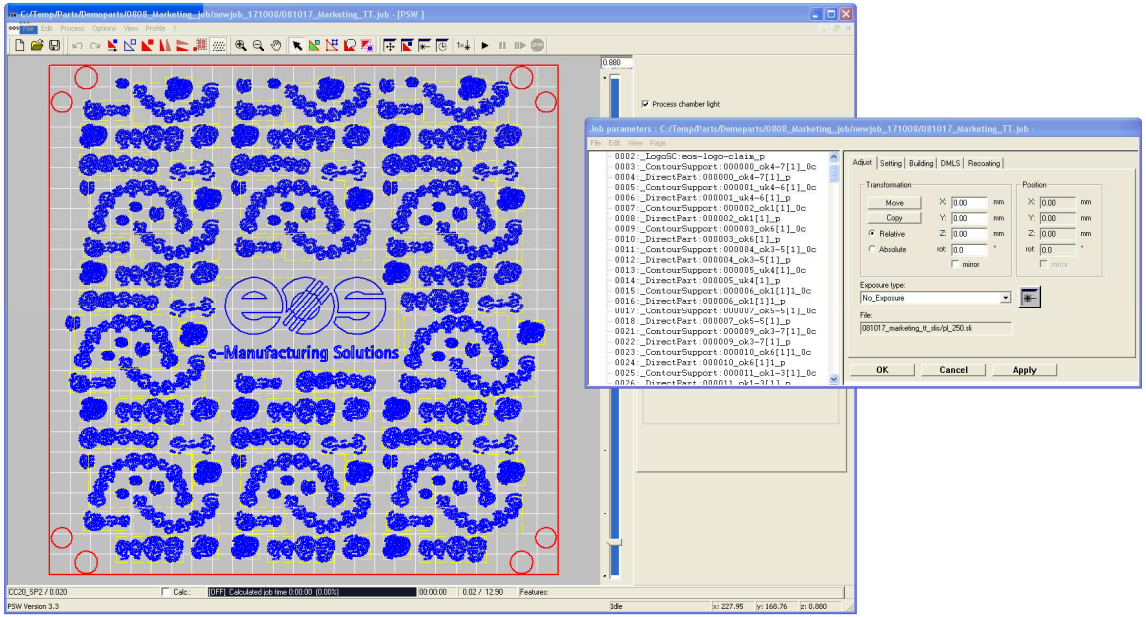
Source: EOS

Data Preparation – Process software

- All SLIs can be loaded into the Process software PSW. The placement and orientation is according to Cambridge.
- The exposure parameters for all files are assigned automatically.







Source: EOS

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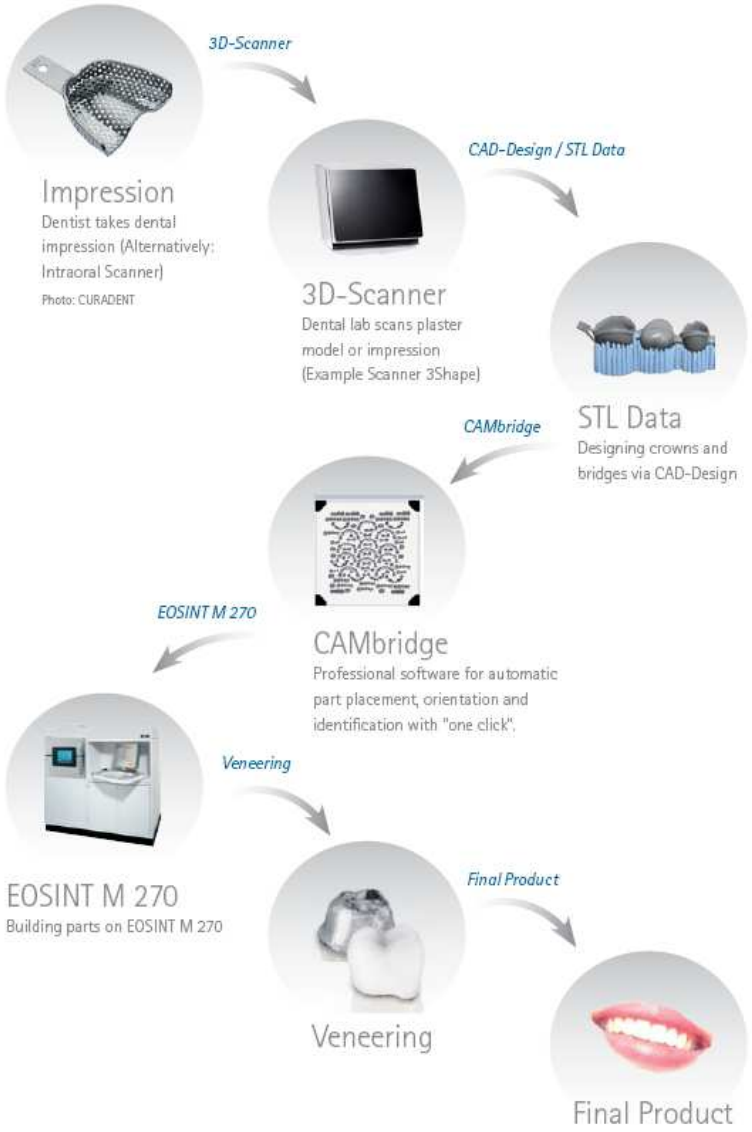
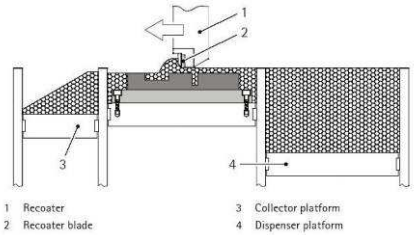
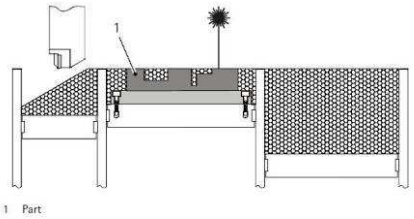


Part Building – EOSint M270

- The parts are build on an EOSINT M270. This system runs a Ytterbium-Fibre-Laser with a nominal output of 200 W.



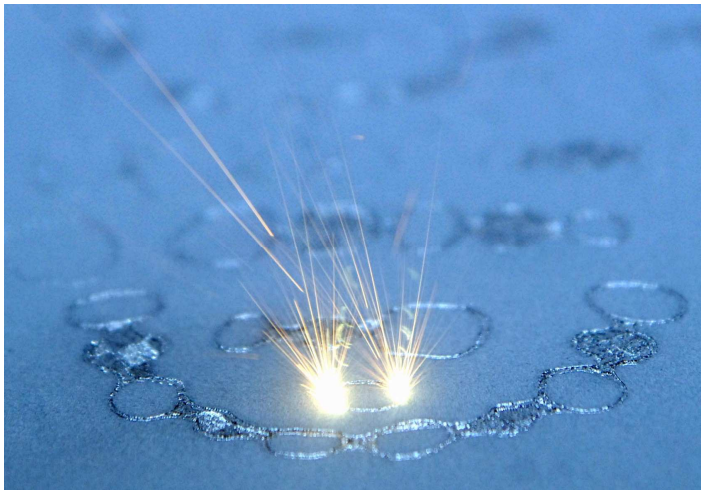
- In the process chamber, the recoater (1) takes material from the dispenser platform (4) and applies 0.02 mm layers on the building platform.
- In the next step, the laser exposes one layer of SLIs as seen on the PSW.



- After that, the platform is lowered 0.02 mm and a new layer of material is applied.

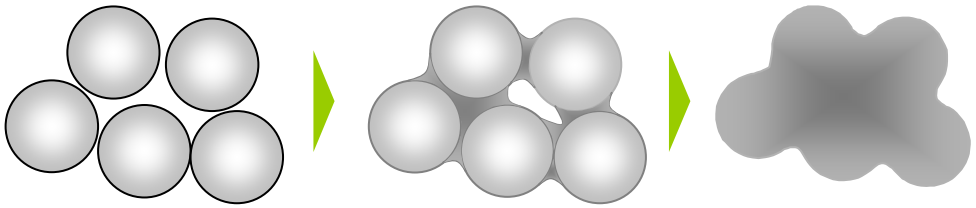
Source: EOS

Part Building



- Between 350 and 600 units can be produced in one job.

- SP2 is a single component material and is melted completly. It consists of
  - Co 62-66 wt-%
  - Cr 24-26 wt-%
  - Mo 5-7 wt-%
  - W 4-6 wt-%
  - Si max. 0.8 - 1,5 wt-%
  - Mn max. 1,5 wt-%
  - Fe max. 0,7 wt-%

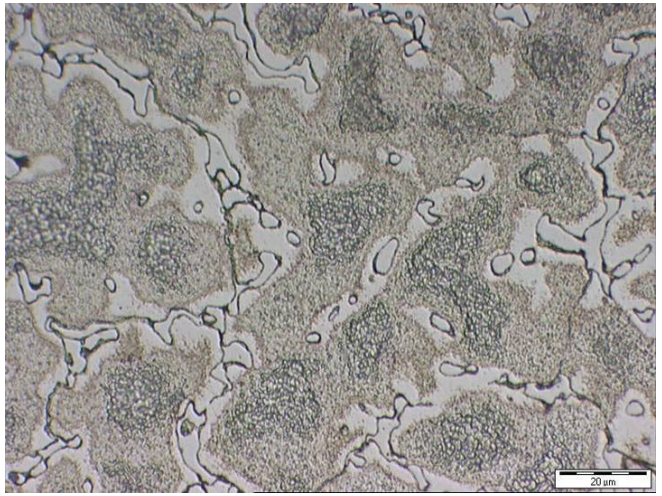


- The building time for a full platform is around 22 hrs.

Source: EOS

Metallurgy – CobaltChrome casted

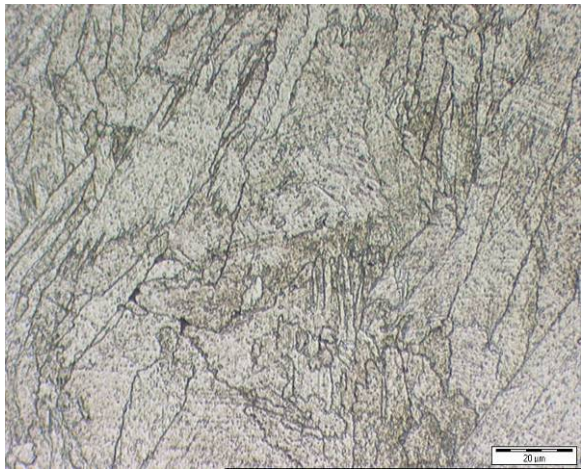
—during the casting there is a risk of overheating and segregation



Source: Flussfisch GmbH/D

Metallurgy – CobaltChrome sintered

- quick solidification after melting leads to a fine and homogenious microstructure.



Source: Flussfisch GmbH/D

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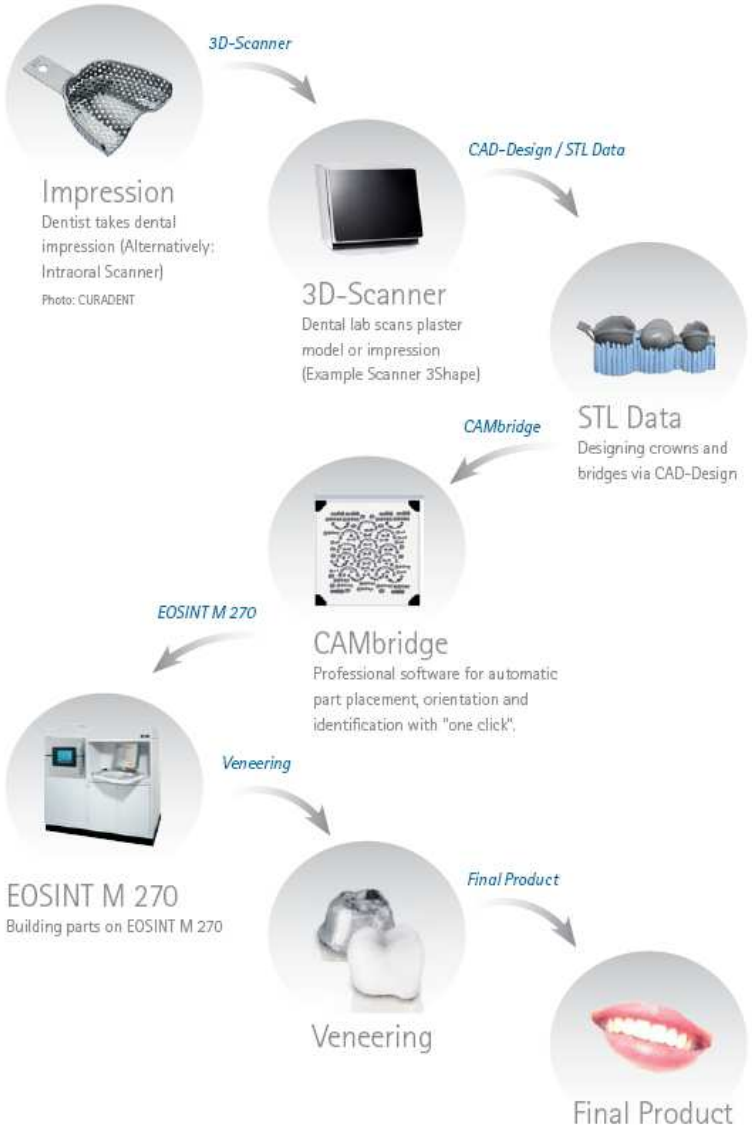
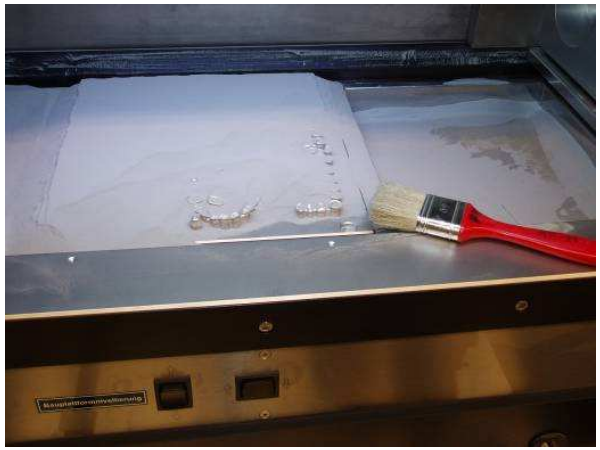


Postprocessing – Unpacking of the Job

- After the building process, the platform is brushed off and the material is sieved inside the building chamber.



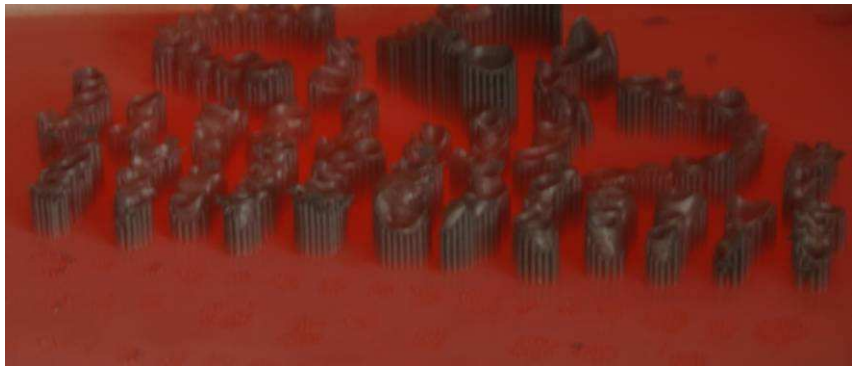
- The parts are shotpeened with ceramic. Shotpeening removes powder particles sticking to the parts.

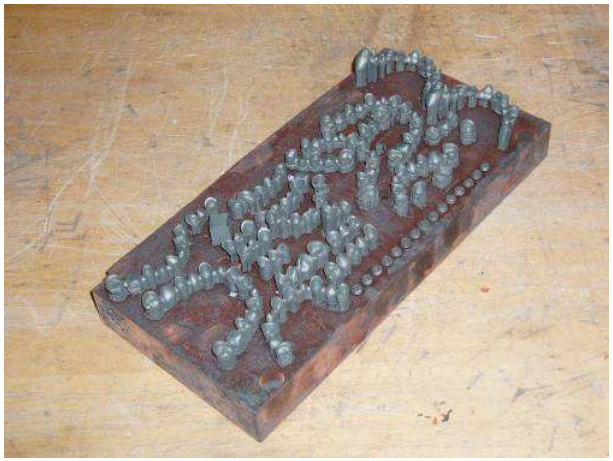
Source: EOS

Postprocessing - Stressrelieve

- Internal stress can appear when building large bridges or big pontics.

- This stress can be minimized by heat treating the parts. The heat treatment runs under Argon atmosphere.

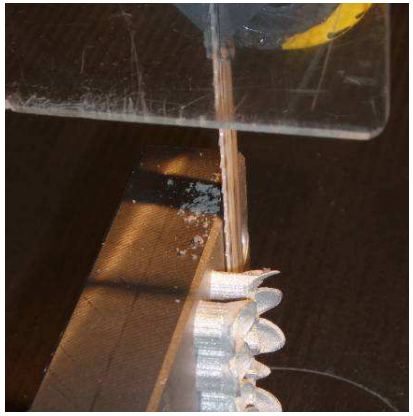




Source: EOS

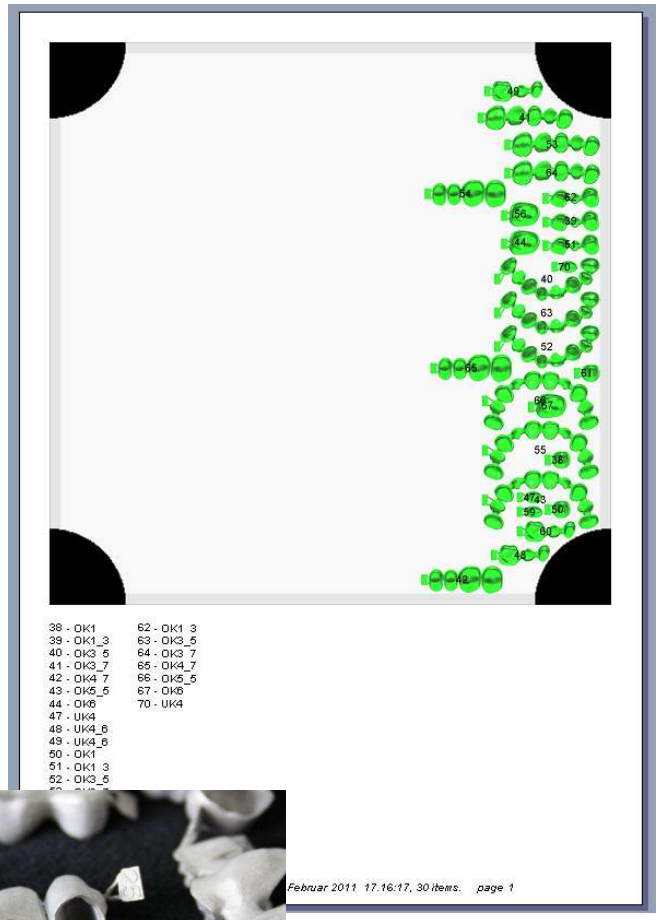
Postprocessing – Cutting off Parts

- The parts are cut off the platform with a band saw.



- The support can easily be removed with a pliers.

- ID-tags and the job print-out help to sort the parts



Source: EOS

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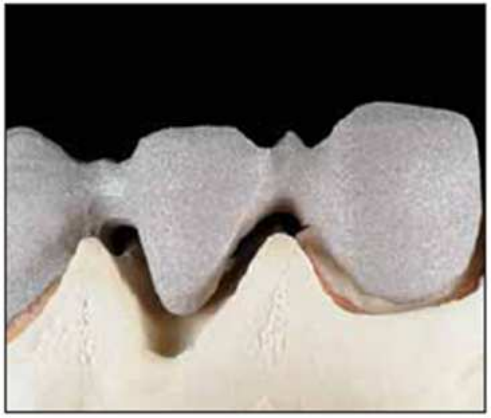
Veneering Preparation

- The veneering surface is finished with a cross-cut drill.

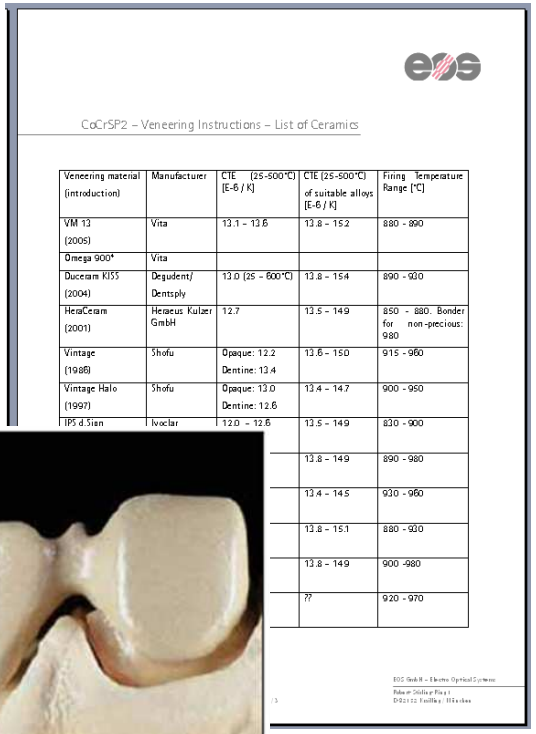
- The surface is blasted with AlO prior and after the oxide bake.



Source: Vita/D

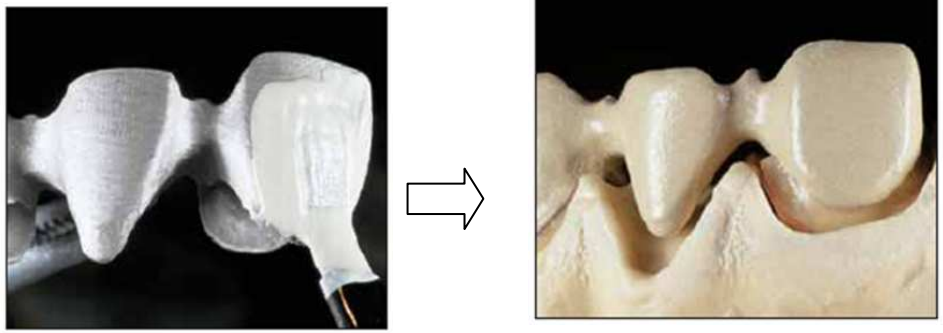
Veneering

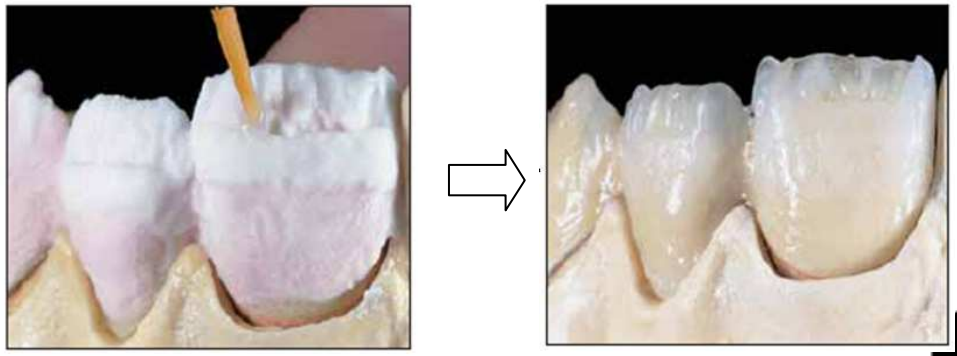
- EOS supplies a list of suitable ceramic materials.
- The opaque is applied in two bakes.
- The crowns are build up with two dentin bakes.



CoCrSP2 – Veneering Instructions – List of Ceramics

Veneering material (introduction)	Manufacturer	CTE (25-500°C) [E-6 / K]	CTE (25-500°C) of suitable alloys [E-6 / K]	Firing Temperature Range [°C]
VM 13 (2005)	Vita	13.1 – 13.6	13.8 – 15.2	880 - 890
Omega 900*	Vita			
Duceram KISS (2004)	Degudent/ Dentsply	13.0 (25 – 600°C)	13.8 – 15.4	890 - 930
HeraCeram (2001)	Heraeus Kulzer GmbH	12.7	13.5 – 14.9	850 - 880. Bonder for non-precious: 980
Vintage (1988)	Shofu	Opaque: 12.2 Dentine: 13.4	13.6 – 15.0	915 - 960
Vintage Halo (1997)	Shofu	Opaque: 13.0 Dentine: 12.6	13.4 – 14.7	900 - 950
IPS d.Sign	Ivoclar	12.0 – 12.6	13.5 – 14.9	830 - 900
			13.8 – 14.9	890 - 980
			13.4 – 14.5	930 - 960
			13.8 – 15.1	880 - 930
			13.8 – 14.9	900 -980
			??	920 - 970





Source: Vita/D

Veneering

- After the glazing bake, all metallic surfaces are polished and the restauration is ready for insertion.

Source: Flussfisch GmbH/D – Vita/D

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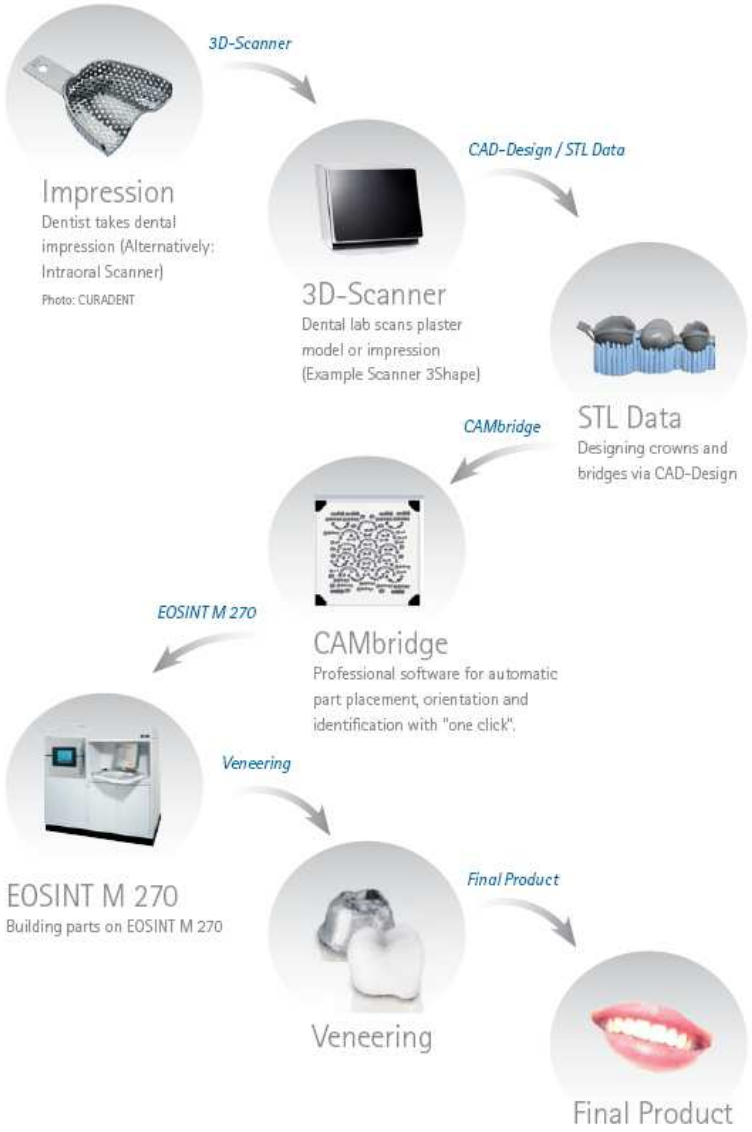
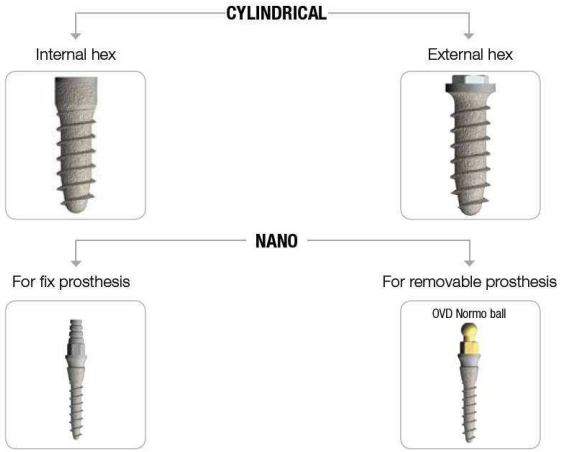


Customer Case/Future Applications

CE certified Implants in Ti64

Project summary

- Requirements:
  - series production of dental implant screws in titanium
  - fulfilment of all requirements for sale of medical devices
- Solution:
  - Production on EOSINT M 270
- Result:
  - economic series production of different product variants
  - CE certified



LEADER ITALIA

Details see:

www.leaderitalia.it

Source: Leader Italia srl (NovaxaTeam)

Customer Case/Future Applications

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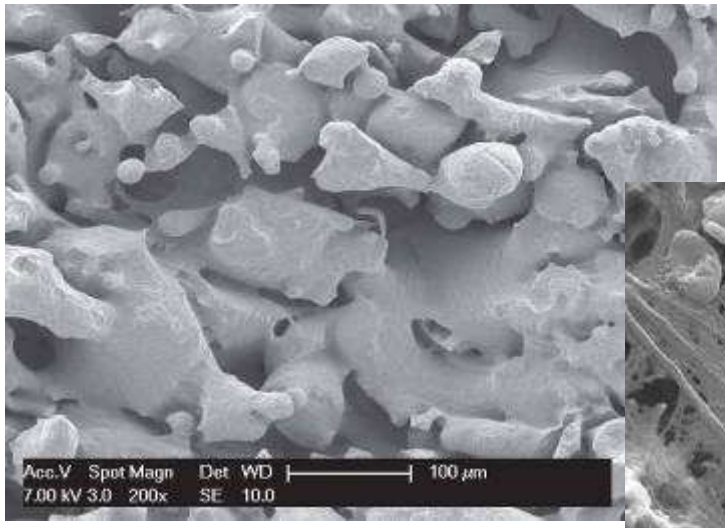
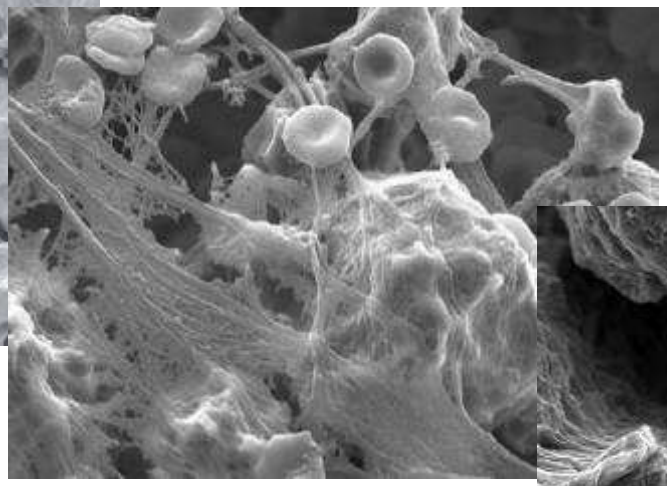
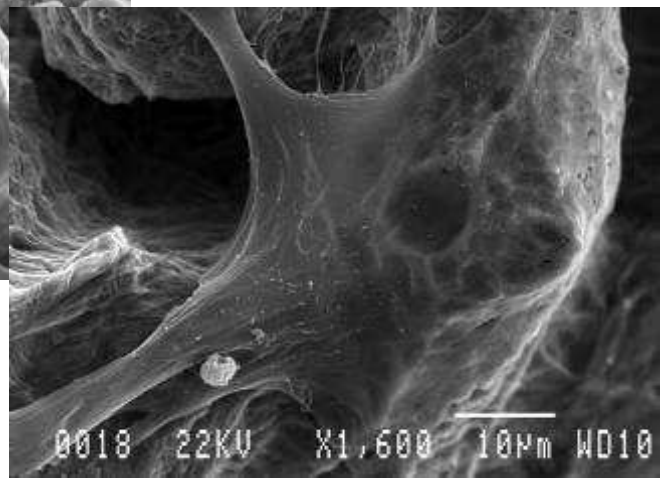


1. Surface determined by the laser process. Pores are interconnected



2. Immediate 3D organization of fibrin network



3. High adherence and cell activity

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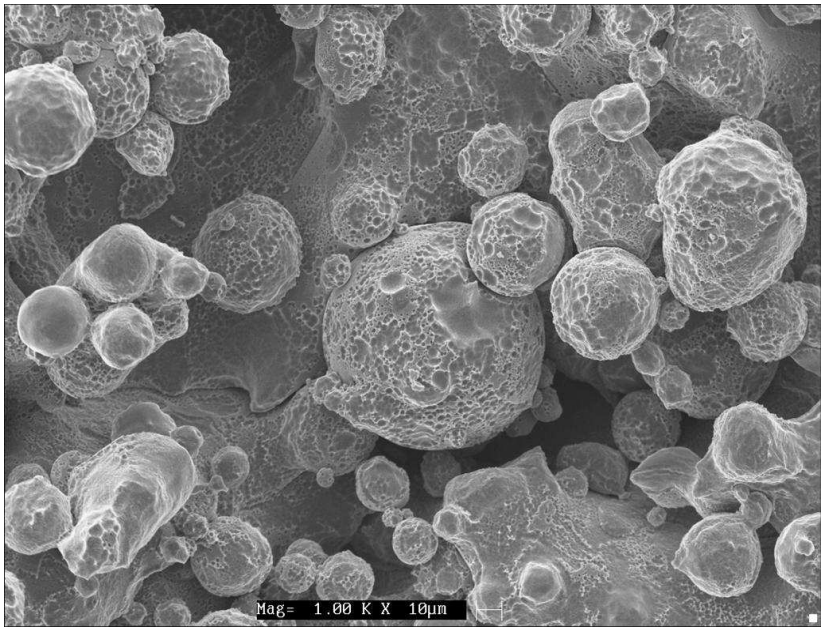
Details see:

www.leaderitalia.it

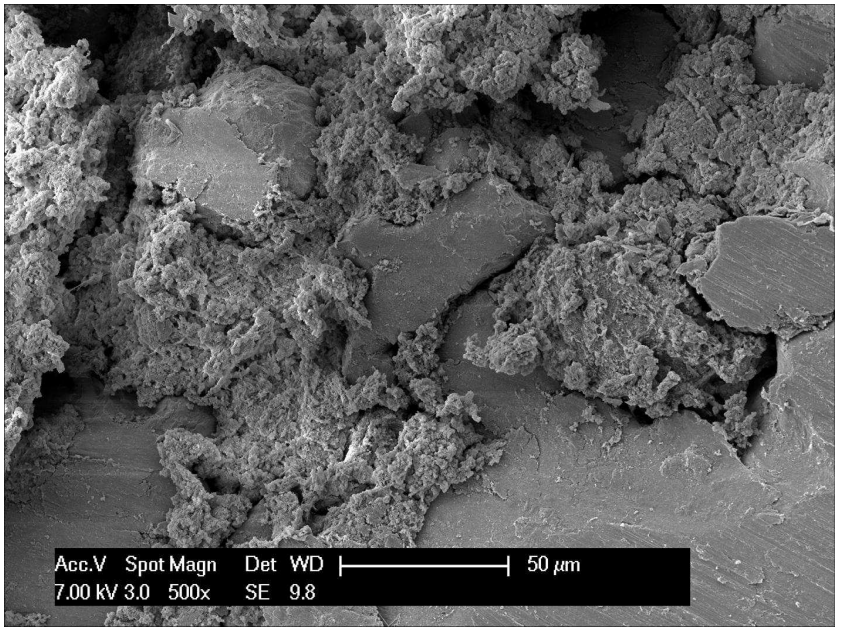
Source: Leader Italia srl (NovaxaTeam)

Customer Case/Future Applications

CE certified Implants in Ti64



1. Ultimate dimension of implant cavities surface just before bone insertion



2. New bone growth inside cavities and pores of sintered titanium surfaces in human after 8 weeks

LEADER ITALIA

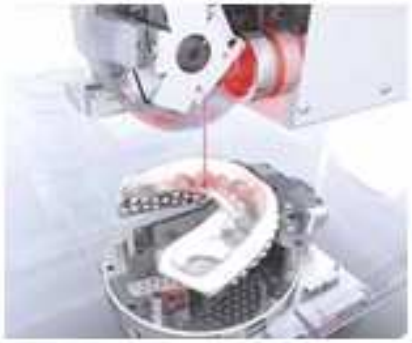
Details see:

www.leaderitalia.it

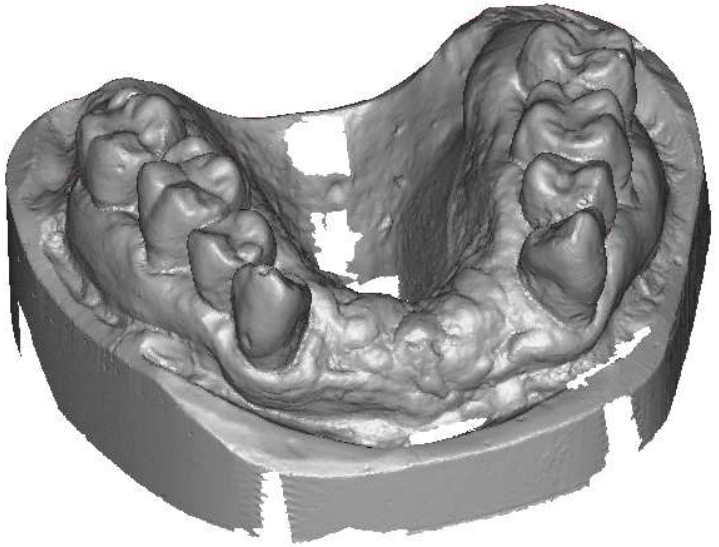
Source: Leader Italia srl (NovaxaTeam)

Future Applications – Dental Models

— New applications generate data of models.



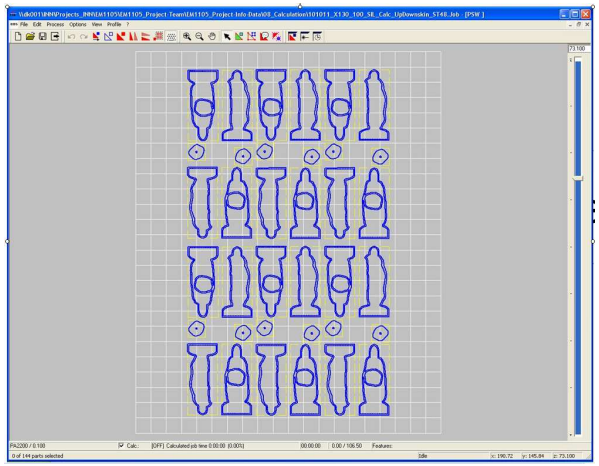
— How to generate models?

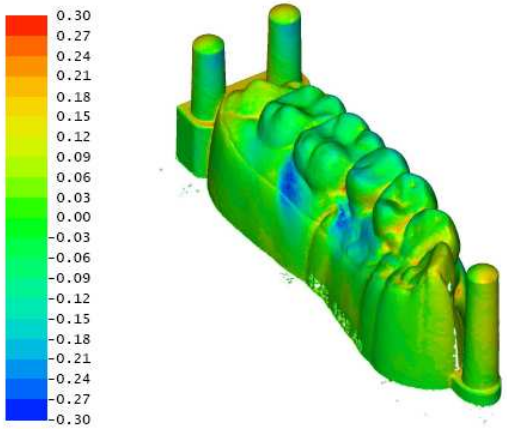


Source: EOS

Future Applications – Dental Models

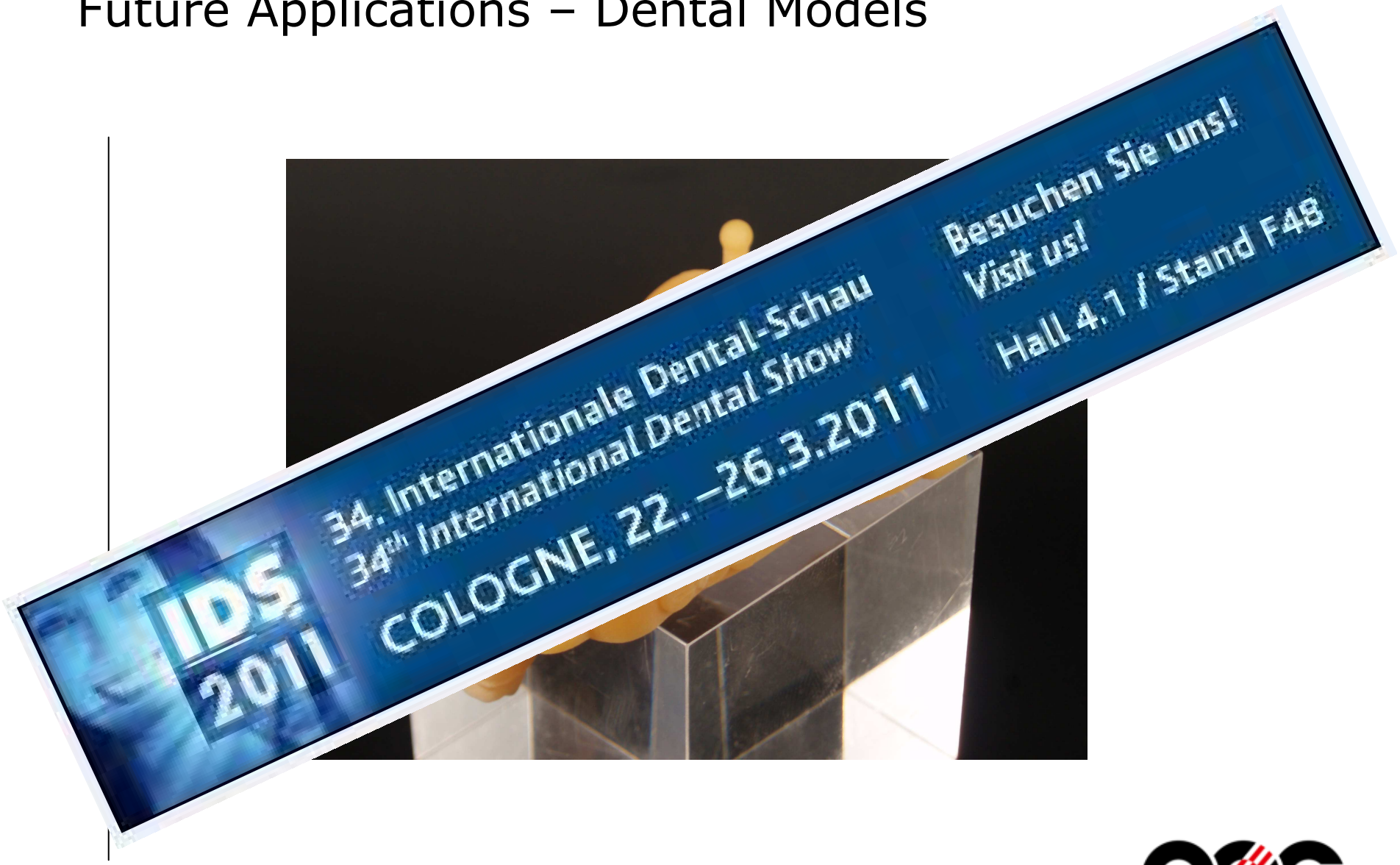
- Formiga P100 Plastic sintering system
- Layer thickness for dental models 60µm





Source: EOS

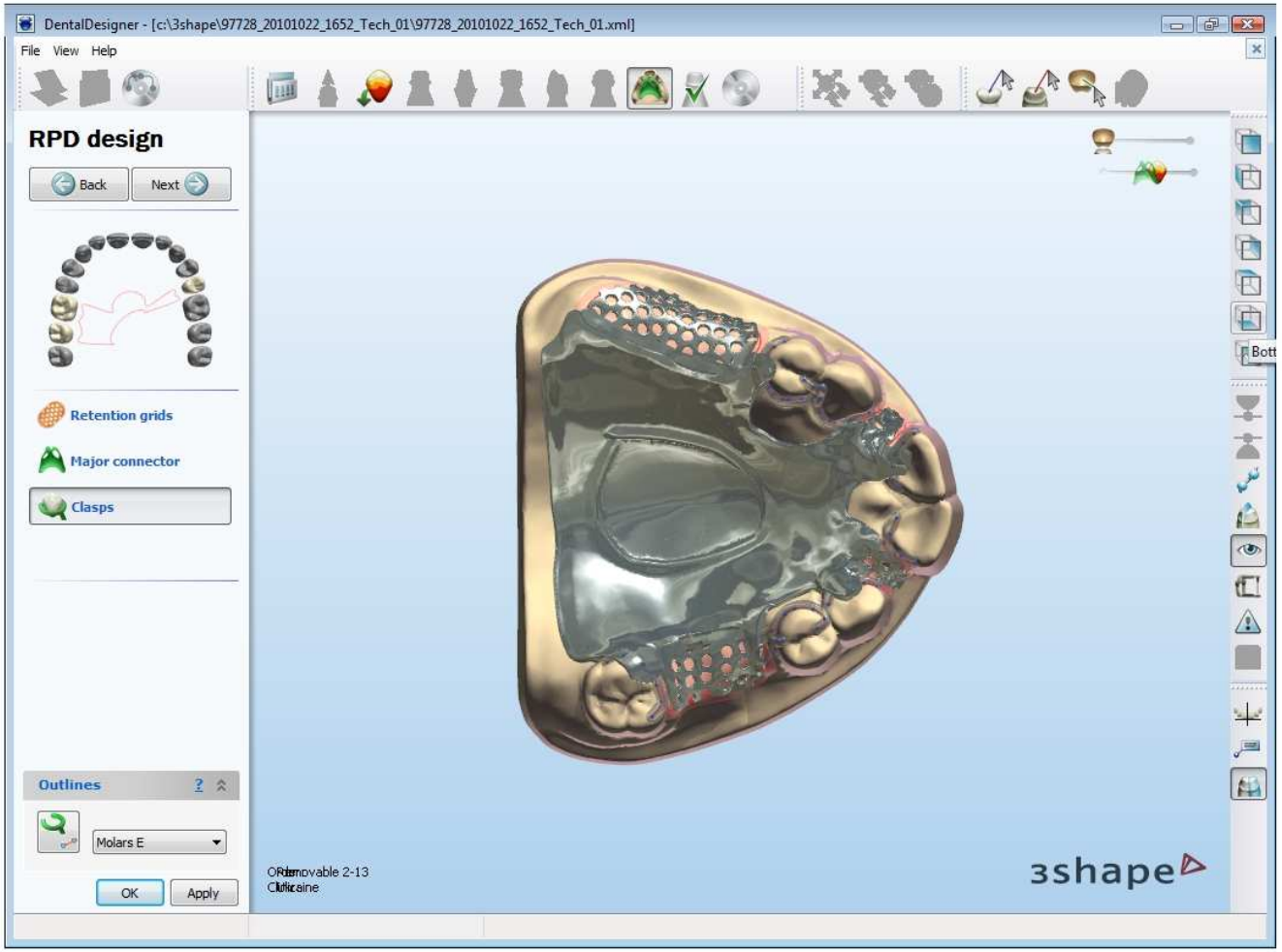
Future Applications – Dental Models



Source: EOS

Future Applications – Removable Partial Dentures

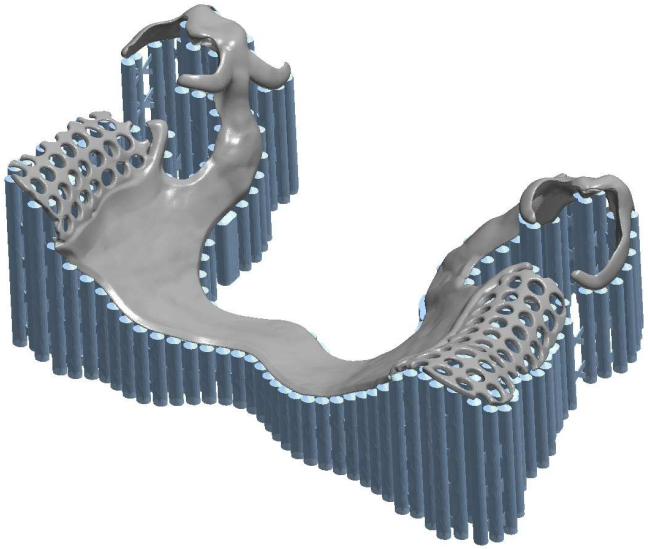
— Advanced CAD software allows the design of Removable Partial Dentures

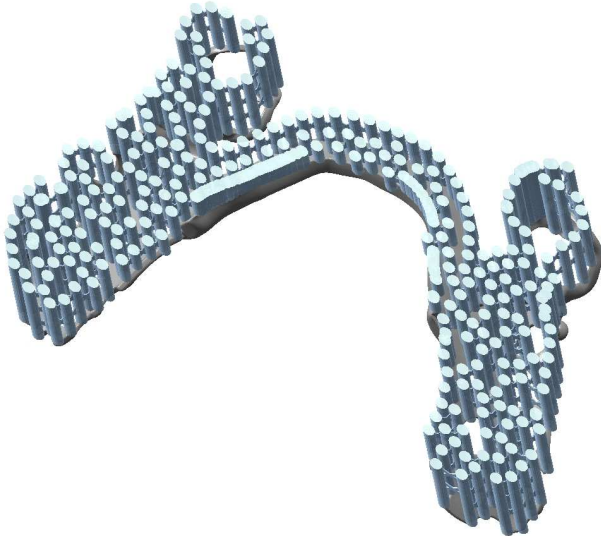


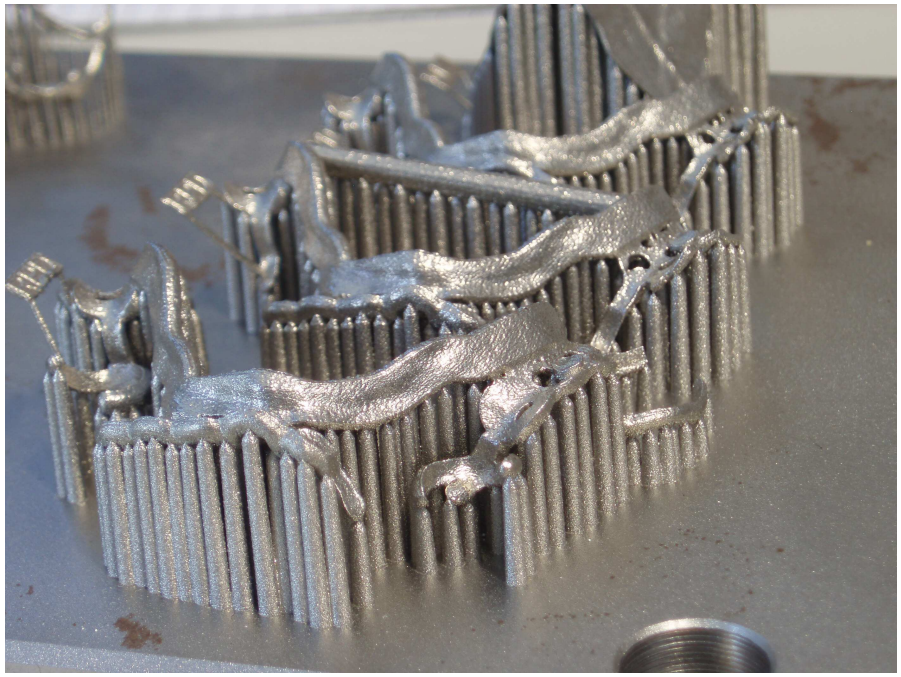
Source: 3Shape

e-Manufacturing Solutions

Future Applications – Removable Partial Dentures



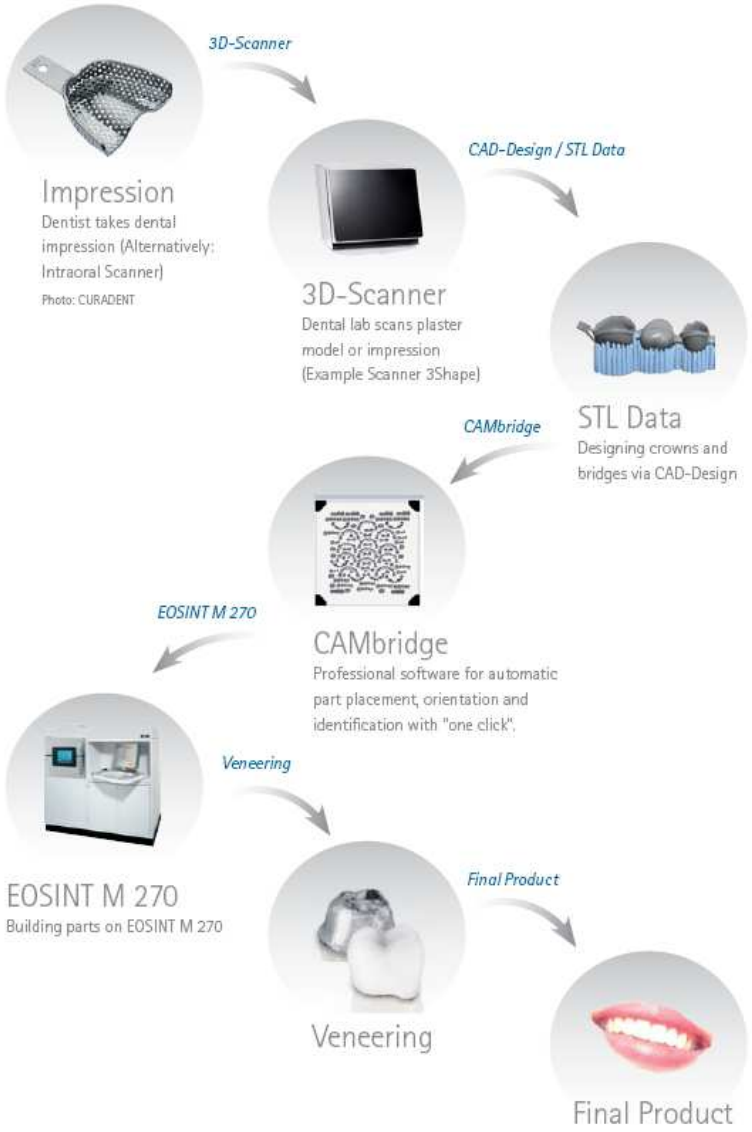




Source: EOS

Dental Process Chain

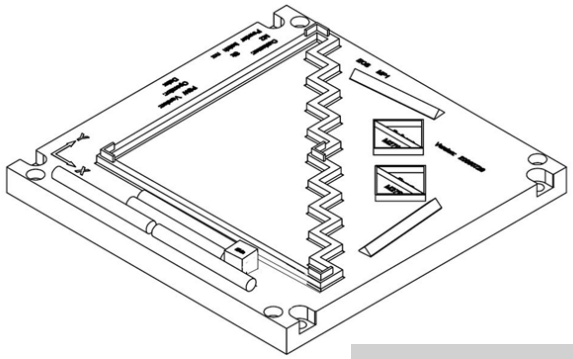
- Overview EOS – Layer technology
- Dental Scanning/Design
- Data Preparation
- Part Building
- Postprocessing/Veneering
- Customer Cases/Future Applications
- **Quality Assurance**



Quality Assurance

QA of EOSINT machines

- EOS has thorough quality assurance procedures for the manufacture of EOSINT machines
- All relevant stages in the supply chain and production are subject to documented quality assurance procedures (specifications, tests, documentation etc.)
  - at (sub-) suppliers via quality assurance agreements
  - within EOS via Quality Management System (ISO 9001)



Factory certification

M270D – SI ____

During assembly at EOS GmbH, the following settings, calibrations and function tests have been performed successfully on the machine:

Mechanics
The working plane and the recoater have been adjusted
The recoater axis has been adjusted and is functional
The dispenser system has been adjusted and is functional
The level monitoring has been adjusted and is functional
The pneumatic system and nitrogen supply have been adjusted and are functional
The electrical safety test has been performed

Optics system
The laser meets the process requirements
The scanner has been aligned and calibrated, and is functional

Process
The focus has been adjusted
The skywriting has been adjusted
The EOS qualification job has been built, checked, documented and, if necessary, the parameters adjusted

related aspects during assembly, all measurements and tests are according to EN 60204-1:2006/A1:2009, emergency-stop-circuit and safety-circuit were checked with positive results so that the system can be delivered without reservation.

Inspector: _____

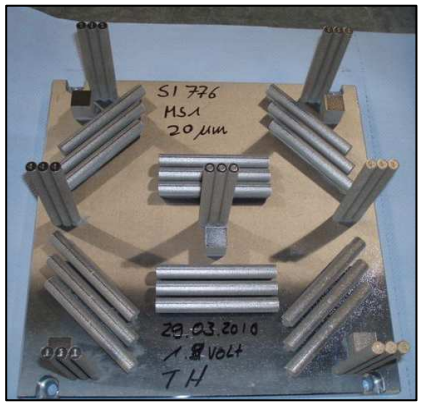
Date: _____

Left: QA job built on every EOSINT M machine
Right: Factory certificate, issued for every EOSINT M machine

SOURCE EOS

Quality Assurance

Measurement of density and mechanical properties

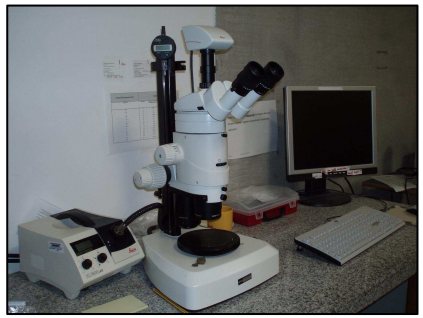


EN ISO 3369 „Impermeable sintered metal materials and hardmetals - determination of density"

Zwick / Roell Z050, max. force 50kN, force accuracy according to ISO 7500-1, extensometer accuracy according to ISO 9513

Measurement of porosity, microstructure etc.

Struers devices for sample preparation



Microscopy setup

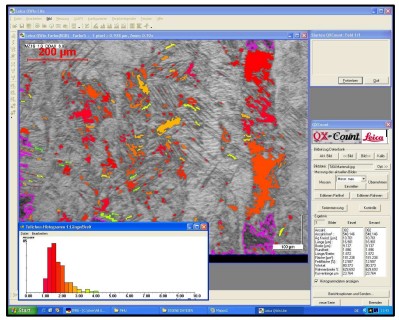


Image analysis (phases, porosity etc.)

Source: EOS

Quality Assurance

Material data

—The part properties are published in our material data sheets

—Various data are measured and published:

- mechanical and thermal properties
- as-built and heat treated
- Coefficient of thermal expansion

—Examples of tests performed on production batches of powder materials

- chemical analysis
- grain size analysis
- samples of powder and specimens are archived from each batch
- powder properties are documented in

Mill Test Certificates for each batch

Mechanical properties of parts at 20 °C, in as manufactured condition, (according to EN ISO 22674:2006)

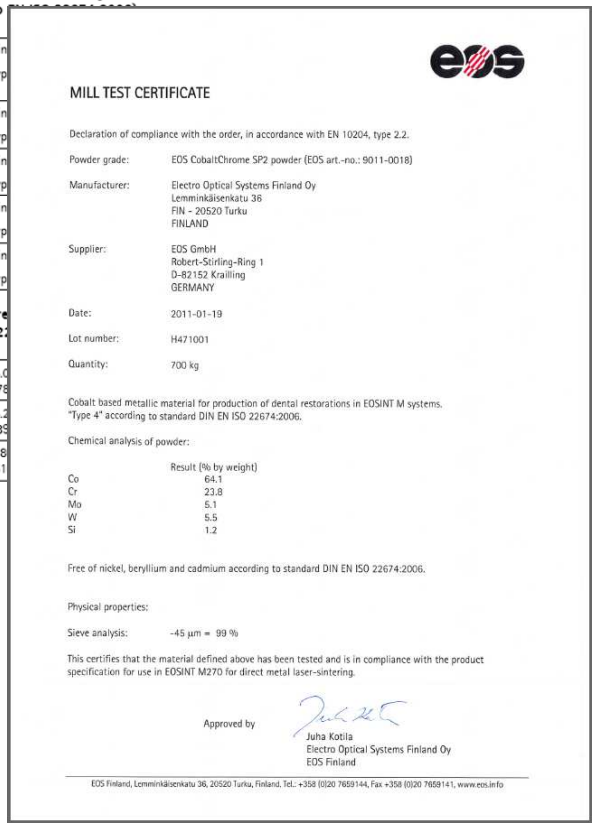
Ultimate tensile strength	Min.: 800 MPa, 116 ksi (typical: 1050 ± 100 MPa, 152 ± 15 ksi)
Proof strength (Rp 0.2 %)	Min.: 600 MPa, 87 ksi (typical: 750 ± 80 MPa, 109 ± 12 ksi)
Elongation at break, A5	Min.: 10 % (typical: 14 % ± 2 %)
Young's Modulus	Min.: 170 GPa (typical: 200 ± 20 GPa)
Hardness HV10	Min.: 320 HV (typical: 360 ± 20 HV)

Mechanical properties of parts at 20 °C, after stress relieving at 750 °C for 1 hour and firing at 880 °C for 5 minutes, (according to

Ultimate tensile strength	Min (typ
Proof strength (Rp 0.2 %)	Min (typ
Elongation at break, A5	Min (typ
Young's Modulus	Min (typ
Hardness HV10	Min (typ

Thermal properties of material, after stress re 880°C for 5 minutes, (according to EN ISO 2

Coefficient of thermal expansion (25 - 500 °C)	14.0 7.78
Coefficient of thermal expansion (20 - 600 °C)	14.2 7.89
Melting interval	138 251



MILL TEST CERTIFICATE

Declaration of compliance with the order, in accordance with EN 10204, type 2.2.

Powder grade: EOS CobaltChrome SP2 powder (EOS art.-no.: 9011-0018)

Manufacturer: Electro Optical Systems Finland Oy
Lemminkäisenkatu 36
FIN - 20520 Turku
FINLAND

Supplier: EOS GmbH
Robert-Stirling-Ring 1
D-82152 Krailling
GERMANY

Date: 2011-01-19

Lot number: H471001

Quantity: 700 kg

Cobalt based metallic material for production of dental restorations in EOSINT M systems. "Type 4" according to standard DIN EN ISO 22674:2006.

Chemical analysis of powder:

	Result (% by weight)
Co	64.1
Cr	23.8
Mo	5.1
W	5.5
Si	1.2

Free of nickel, beryllium and cadmium according to standard DIN EN ISO 22674:2006.

Physical properties:

Sieve analysis: -45 µm = 99 %

This certifies that the material defined above has been tested and is in compliance with the product specification for use in EOSINT M270 for direct metal laser-sintering.

Approved by
Juha Kotila
Electro Optical Systems Finland Oy
EOS Finland

EOS Finland, Lemminkäisenkatu 36, 20520 Turku, Finland, Tel.: +358 (0)20 7659144, Fax +358 (0)20 7659141, www.eos.info

Source: EOS

Summary Advantages EOS Process for Dental

Productivity:	High productivity, 450 units in only one platform
Industrial Quality:	Industrial system with German quality and reliability
Dental powder:	CE marking for the Co-Cr SP2 powder
Technical Service:	75 service technicians world-wide
Application support:	2 application engineers (Master Dental Technician, Dental Engineer) for customer support in Dental applications
Company:	70 personnel on R&D tasks
Legal Protection:	EOS GmbH owns a large patent portfolio relating to laser sintering technology, including rights licensed from BEGO Medical GmbH for the production of dental prostheses and related products using laser sintering technology.

Established Solution: More than 35 systems sold world wide

Source: EOS



Any shape · Anytime · Anywhere

Thank you for your attention

www.eos.info

e-Manufacturing Solutions