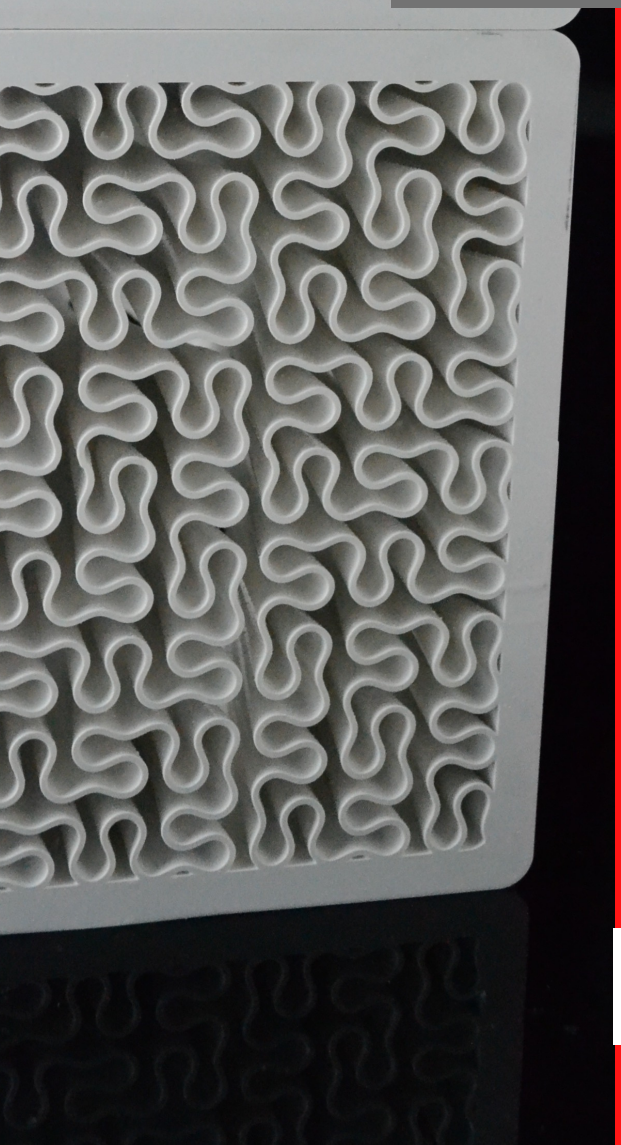
02/2021

Additive Manufacturing for industrial applications



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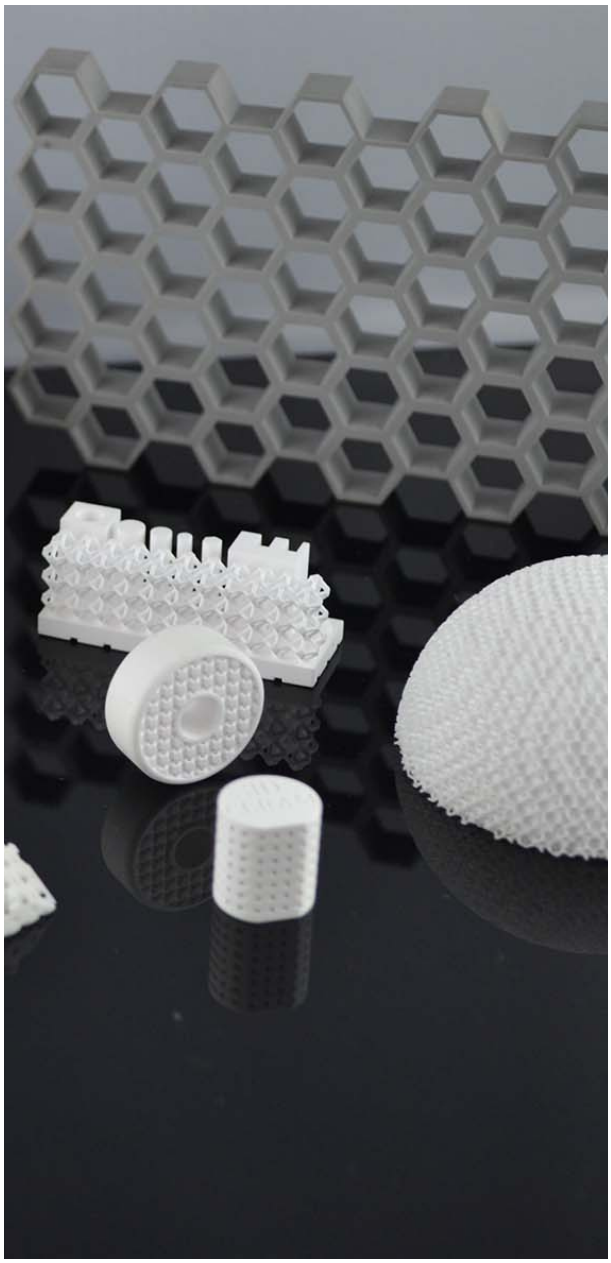
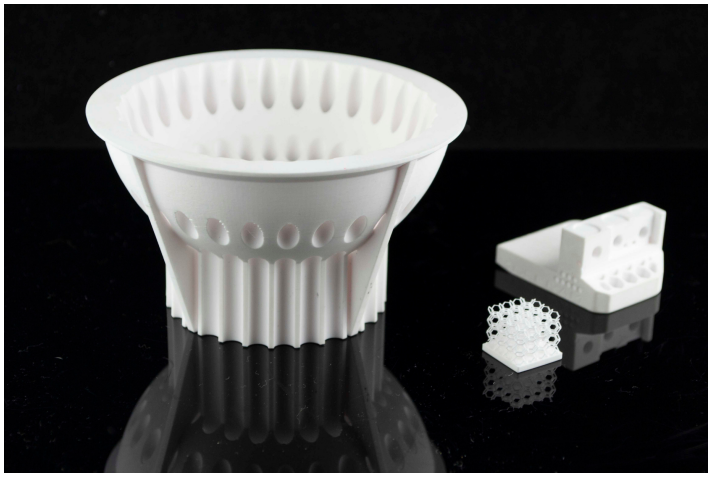


Highly specific mechanical, electrical, thermal and chemical properties of advanced ceramics make ceramic additive manufacturing technology expand rapidly into different industrial segments: chemistry, oil & gas, water treatment, electronic, automotive and other industries.

3D ceramic printing makes new complex parts that are difficult to produce using traditional methods possible. It allows manufacturing of parts without expensive tooling, which is particularly interesting in cases of small series production, individually designed parts or freedom to change the design of some engineered components. Also, downtime being critical for any industrial process, production companies may create their own additive manufacturing facilities to quickly source several spares and wearing parts, especially for old equipment.
The COVID-19 pandemic brought much of the world to a standstill, and has forced us to question many things. In the manufacturing world, for instance, there is now an increased focus on localized on-site production, as supply chain disruptions were the source of many problems when COVID-19 hit.

This crisis has revealed just how volatile supply chains can be. Additive manufacturing has been touted as a potential solution, especially as it has proved so useful in the rapid production and deployment of essential products like PPE and nasal swabs.
So, what kind of impact can the disruptive technology of 3D ceramic printing have on different industrial segments in the future?



Industrial applications of technical ceramics are defined by theproperties of materials:

- **Filtering of fluids and gases** because ceramics are chemically inert and are resistant corrosion and temperature applications include filters, dies, tooling, gaskets, tightness rings;
- High temperature applications: **injectors, nozzles**, temperature probes, pressure and temperature sensors, heating components, heat recovery components;
- **Electronic insulation**: insulation components, connectors, inserts, tubes with cooling channels inside, different insulation disks and bushings;
- Sanitary applications: handles for tools in contact with food or medical substances;
- Heat exchange: **heat exchangers** with internal channels, furnace inserts for cooling;
- Electronics for electrical insulation and ionic conduction properties of ceramics: honeycomb solar absorbers, antennas (for satellites, 5G, drones etc..), rigid supports for electronic devices, housings for components, parts for infrared emitters, induction coils;
- Medical tooling and equipment: tools for catheters, supports for optical filters;
- Various wearing parts because of resistance to abrasion of ceramics and longer life cycle of ceramic parts: different kinds of nozzles for fluids and gases etc.;
- Different hardware because of good mechanical resistance and stiffness: clamps, fixing supports, housings etc.
- Decoration functional components because of aesthetic properties of ceramic materials

Mass customization: evidence by ROI

Additive manufacturing brings a new dimension to the conventional industrial process. In addition to saving time and increasing productivity, 3DCERAM's breakthrough technology delivers the following benefits:

Flexibility of design
Increased complexity for better efficiency of parts
Quick creation of new designs
Better responsiveness and productivity
Increased profitability

Increasing productivity of the 3D printing process is one of the challenges to integrate this technology by industrial players. Our range of printers meets this requirement. Quick prototyping and cost-effective R&D works thanks to the use of our C100 Easy platform (100 x 100 x 150 mm) and simply scaled up for industrial serial production with the printer C3600 Ultimate. Using this lab to fab "winning tandem" we can ensure efficient engineering and quick integration into a industrial scale production process providing a large number of parts per printing cycle, and hence maximize the ROI in the medium term.

All other things remaining equal, the use of C3600 Ultimate printer evidenced the cost price drop of more than 30% comparing to smaller, C900 Flex printer with printing platform of 300 x 300 x 100 mm.

Choice of materials

The choice of ceramic is a very important part of the 3D printing process and is in close connection to the final properties of parts we look for. There are some important points that the manufactures must take into account whendeciding on which ceramic to use:

- The mechanical properties: strength, stiffness, hardness, wear resistance
- The thermal properties: thermal conductivity, resistance to thermal shocks, CTE
- The chemical inertness or compatibility of ceramic materials in contact with the fluids or gases
- The electrical properties: electrical insulation and resistivity, ionic, oxygen-ionic conductivity..

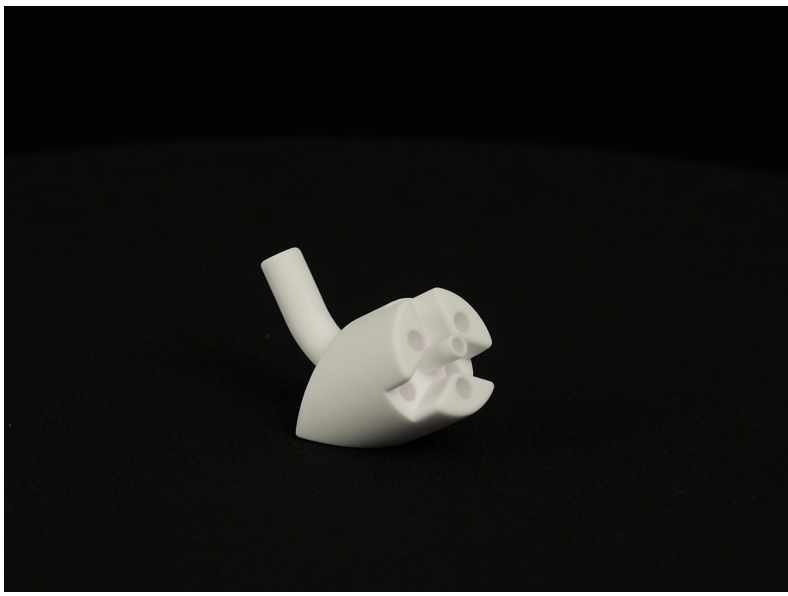
3DMIX

3DCERAM has been developing their own line of pastes, 3DMix, to use in conjunction with their 3D printing machine the CERAMAKER ® 900 and related models (C100, C3600). We have developed a range of pastes and suspensions to achieve optimal printing results. These pastes have been developed to provide a product equal to traditional methods. 3DCERAM have optimized their paste according to the customer's criteria in many cases, in the form of on-demand development of ceramic paste to conform to the machine's parameters.
This has allowed customers to use their own certified ceramic powders while using the breakthrough technology of ceramic 3D printing.

Ceramics portofolio

Alumina (Al_2O_3)
Used more often than any other advanced ceramics. Very good mechanical resistance, electrical resistance, high hardness, corrosion and wear resistance, high operating temperature and chemically and bio- inert.

Zirconia (ZrO_2)
Useful in surgical instrumentation and odontology prosthesis (crowns and bridges), porous coating dentistry: material with very good mechanical properties, great hardness, good wear resistance, corrosion resistant.

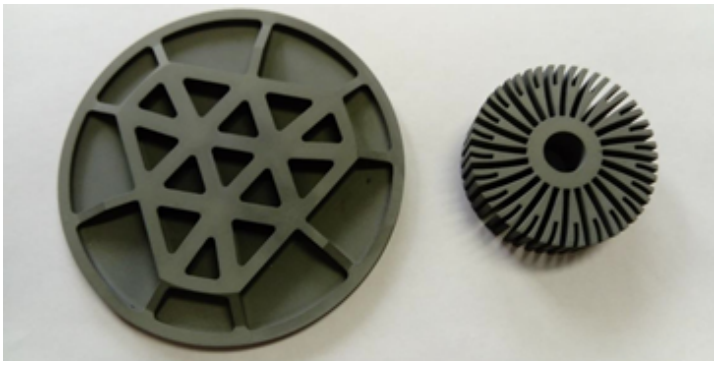


Silicon Nitride
One of the hardest and most thermally resistant ceramics.
The main characteristics of silicon nitride are: low density, excellent resistance to thermal shock, excellent resistance to wear, and low thermal expansion coefficient.

Cordierite
Cordierite is a magnesium alumina silicate with chemical formula 2MgO.2Al2O3. 5SiO2 Cordierite can be used due to low thermal conductivity and low expansion coefficient, resistance to heat and low dielectric loss.

Aluminium Nitride
The main characteristics of aluminium nitride are: high thermal resistance, excellent electrical insulation and good mechanical strength. Main application of this material is electronic industry.

Zirconia 8Y
This material has excellent ionic conductivity and heat insulation properties. Main application of this ceramic material is manufacturing of solid fuel cells.



Alumina toughened Zirconia
The ceramic ATZ combines both Alumina (20%) and Zirconia (80%) ceramics in one. The mix of these two materials offers several properties like great hardness and tenacity, good biocompatibility and high resistance to wear and shocks. Many applications of this material in different industrial sectors like medical or for applications where the wearing resistance is important criteria.

Customized materials

Along with the materials listed here, 3DCERAM can provide on demand services for when a client wishes to develop their 'own' paste for the CERAMMAKER® range of printers. Our team of experts will take into consideration the needs and demands of the customer when creating a new formulation. The process to obtain a new paste for core production is:

- Characteristics of their powder
- Test the reactivity of the paste once mixed with resin.
- Optimization of the
- powder and determination of machine parameters.
- Post process analysis
- Fabrication of benchmark parts to prove efficacy

This approach has proven to be very beneficial to manufactures of cores. Traditional manufacturers have not altered their powder to adapt to new technologies. It is essential to offer the knowledge and expertise of the 3DCERAM Team to potential customers to establish
a synergy between the parameters of the machine and the characteristics of the ceramic powder required to produce the desired outcome.

3DCERAM had a request from a European aerospace client to develop a paste using their powder, this was a great challenge for the experts in 3DMIX, after 12 months of the development process, cores were successfully produced using the client's custom material. Great teamwork!

Conclusion

Additive manufacturing brings a new dimension to the usual industrial process. In addition to saving time and increasing productivity, 3DCERAM's breakthrough technology delivers the following benefits:

- Improvement of the stiffness to mass ratio
- Integration of new functions like cooling channels or thermal insulators
- Simplification and optimization of the interface

Ceramic 3D printing is a way to create breakthrough designs and improvements for both technical and business aspects of unique ceramic materials.

According to a ten-year opportunity analysis paper, produced by Smartech Markets, the future for ceramic additive manufacturing of technical ceramics is bright.

Industrial 3D printing is expected to represent a large revenue opportunity during the forecasted 10-year period 2020-2030. There is an encouraging a shift from research to scale production of technical ceramics. An increase in revenue forecast from 43 million to 1.6 billion is estimated.
For some industrial sectors it is expected that revenues of printed ceramic
parts will increase in very important way:

- Energy: 26 times
- Electronics: 100 times
- Automotive: 66 times

3DCERAM, with our new disruptive technology and expertise are well positioned to provide world-class and innovative technical solutions to the complex future needs of these different markets!