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SUPSI

SLS supports research
on hybrid materials

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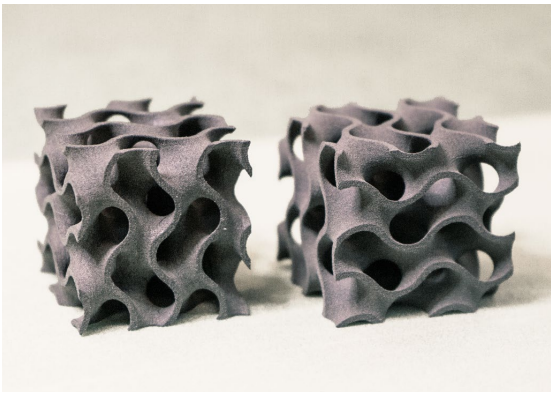
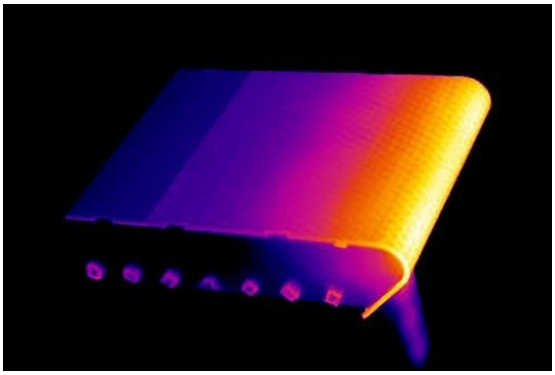
Professor Alberto Ortona
Director of the Hybrid Materials Laboratory at the Institute for Mechanical Engineering and Materials Technology (MEMTi) at SUPSI

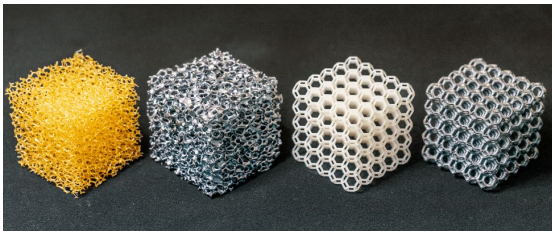
«We will benefit more and more from the possibilities of additive technologies.»



Prototypes of catalyst substrates which swirl the exhaust gas flow: The two gyroid structures have the same size but are 3D printed with different parameters. This leads to diverse micro-porosities and mechanical properties.



Thermal shield: Testing of a leading egde in a plasma wind tunnel. (Image source: German Aerospace Center DLR).



Development process of cellular ceramics for lightweight construction (from left to right): Natural foam cube with heterogeneous „random structure“, the foam template coated with a ceramic paste, 3D printed sacrificial template with structured geometry and the sacrificial template coated with a ceramic paste. (Courtesy of EngiCer SA)

The Hybrid Materials Laboratory at the University of Applied Sciences and Arts of Southern Switzerland (SUPSI) is developing new composite materials. In addition to a wide range of production and analytical equipment, the Ticino researchers also make use of a Sintratec Kit.

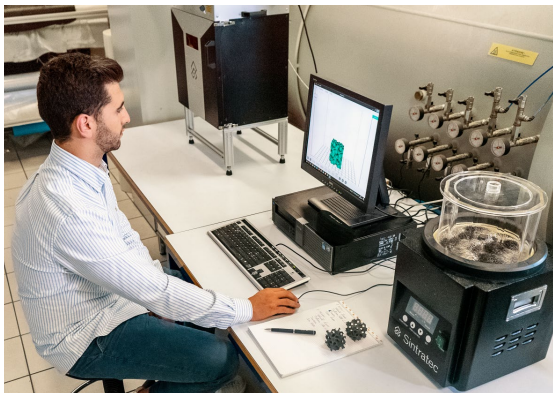
The keyword for aerospace vehicles like NASA's space shuttle is reusability. Professor Alberto Ortona, head of the Hybrid Materials Laboratory at the Institute for Mechanical Engineering and Materials Technology (MEMTi) at SUPSI, says: "A space vehicle enters the atmosphere from a low earth orbit with a speed of roughly 30'000 km/h. The vehicle is then decelerated by the friction of air which converts its kinetic energy into heat. As a result, the outer surface gets extremely hot". For these structures not to burn upon re-entry, special hybrid materials are required – such as structural components made of advanced ceramics, which can withstand extreme conditions in terms of ultra-high temperature and thermal shock over a long period of time. Notably, such kind of components do not have to be replaced after each expedition.

Gas-cooled sandwich structures

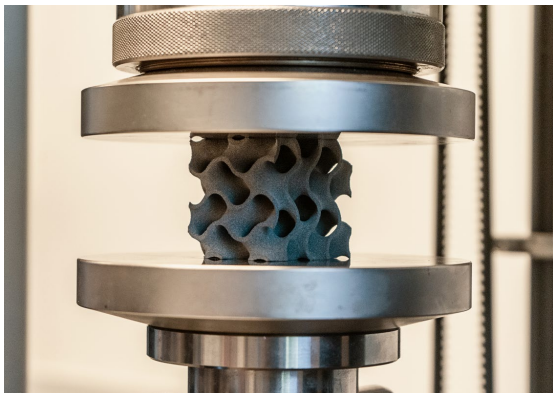
Professor Ortona's team is researching such ceramic hybrid materials for extreme conditions. For the EU research project THOR, for example, his institute developed complex sandwich structures made of ceramic composites that are cooled with gas flows. This enables the thermal behavior of structural components of future space vehicles to be controlled using active „Thermal Protection Systems". The research focus of the world-renowned university is on the engineering of special material combinations, including combinations with air – i.e. porous materials. These include modern structural components through which gases or liquids flow, and which are installed in heat exchangers, heating burners, solar systems, catalytic converters or water filtration systems.

SLS allows complex designs

The so-called Ceramic Matrix Composites (CMC) are particularly suitable for thermally stressed components. Such lightweight lattice architectures represent a class of high-quality intricate components thanks to their high mechanical properties. Their production is often only possible through additive manufacturing.



Simone Vitullo, Research Assistant at MEMTi, at his workplace in the Hybrid Materials Laboratory.



Mechanical strength test of a 40 mm edge cubic gyroid sample: Despite its light structure, the component made of Sintratec PA12 withstood a compression load of up to 5 kN (i.e. almost 500 kilograms).

Oscar Santoliquido, Research Assistant at the Institute for Mechanical Engineering and Materials Technology (MEMTi): „SLS technology allows us to produce complex lattice structures quickly and easily“.

The Hybrid Materials Laboratory has been using 3D printers for 15 years. Stereolithography (SLA), which has so far been the most widely used, is now reaching its limits, especially for complex designs such as gyroids. Further, the production of porous polymers is not possible. To get rid of these weak points, the MEMTi institute looked around for alternative 3D printing processes and came across selective laser sintering (SLS).

Porous structures made of Sintratec PA12

Simone Vitullo, research assistant at MEMTi, used the Sintratec Kit daily for a groundbreaking project. He spent three months investigating the mechanical properties and porosities of 3D printed grid structures with the aim of obtaining the most porous geometries possible without much loss of strength. „To optimize the geometry, weight and density of the gyroids, I systematically changed the sintering temperature, laser speed and layer thickness,“ explains the assistant. He subjected the parts to mechanical compression and torsion tests. The resulting coherences between the printing parameters and the characteristics of the 3D-printed parts are now used for further materials research at the institute.

Sacrificial templates for complex ceramic structures

The MEMTi also focuses its attention to the engineering of ceramic hybrid materials, which are realized using structural templates made of Sintratec PA12. Professor Ortona continues: „We call them sacrificial templates“. The term explains the sophisticated manufacturing process: The polymer template printed in 3D via SLS is coated with a ceramic paste, after which the polymer burns during the subsequent heat treatment. The result is a hollow, ultra-light and highly stable ceramic component. These structures are now produced industrially by the Swiss company EngiCer SA. Oscar Santoliquido, research assistant at MEMTi, adds: „Thanks to the open parameters of the Sintratec Kit, we were able to define the 3D-printed objects with the best properties required to apply the ceramic coating optimally to the template. The SLS technology allows us to create complex grid structures quickly and easily.“

Sacrificial templates for complex ceramic structures

In the future, however, the complex ceramic structures will be produced directly through additive manufacturing. „We will benefit more and more from the possibilities of additive technologies,“ sums up Professor Ortona. The fact that 3D printing is helping to create new engineering paradigms is particularly evident in the field of hybrid ceramics.

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