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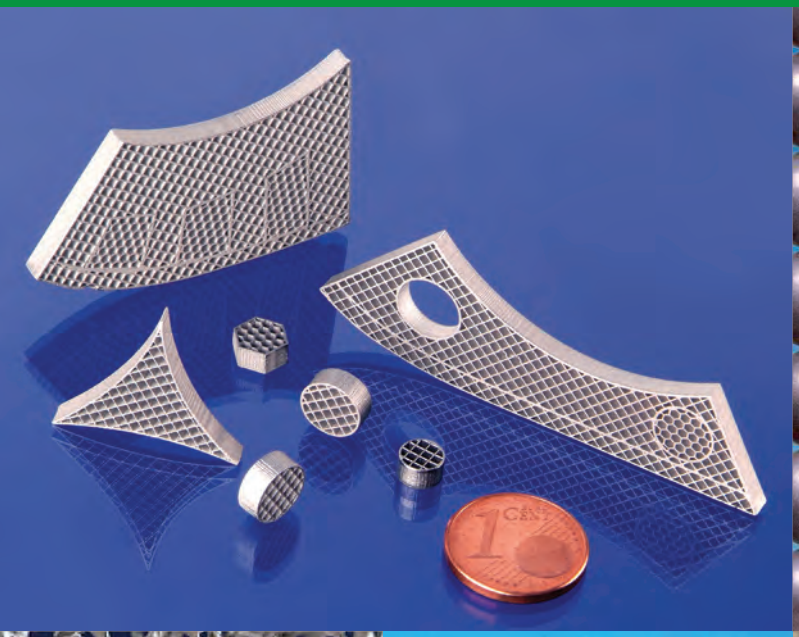
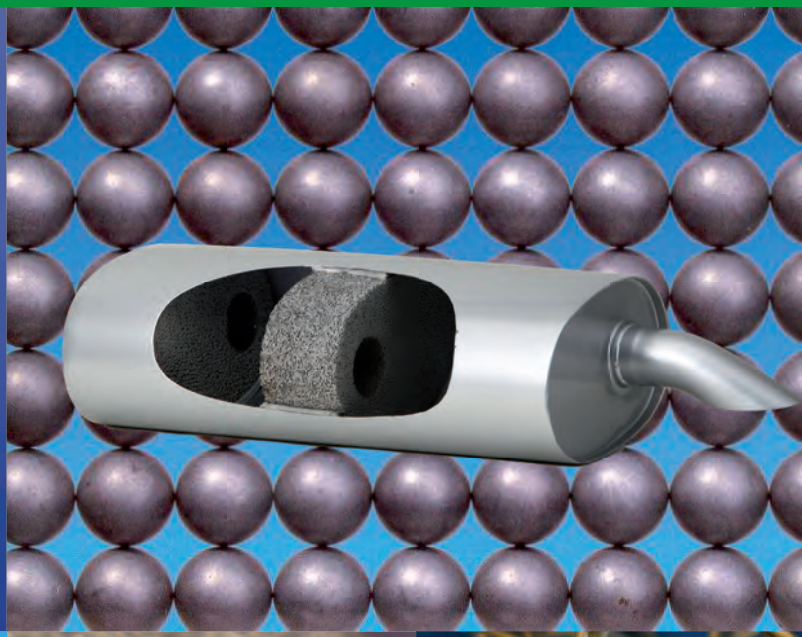
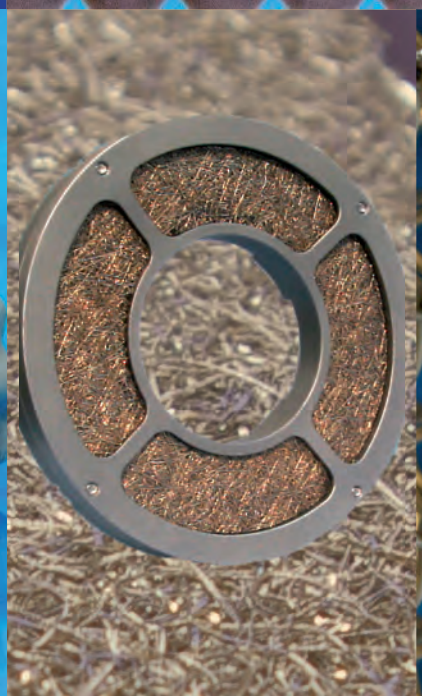
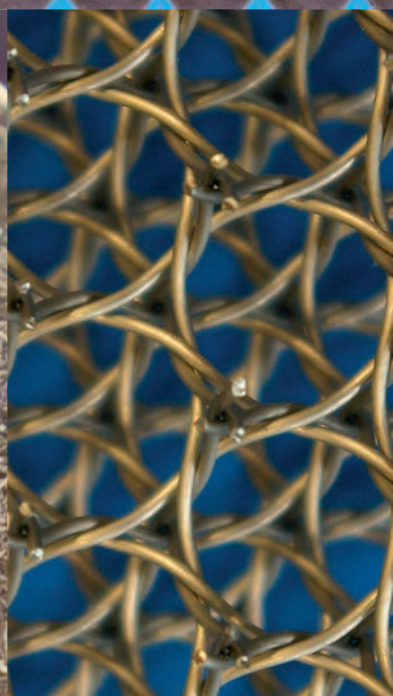
FRAUNHOFER INSTITUTE FOR MANUFACTURING TECHNOLOGY
AND ADVANCED MATERIALS IFAM, BRANCH LAB DRESDEN

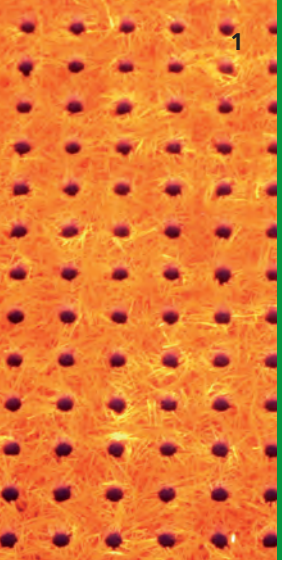
CELLULAR METALLIC MATERIALS

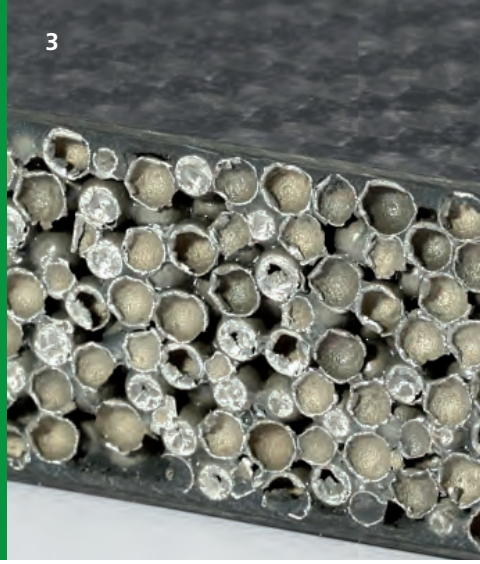












MULTIFUNCTIONAL MATERIALS

Reduced material consumption in automobiles, machines and apparatuses is a permanent challenge of industry, since resources may be protected and energy and cost values reduced this way. With this objective, innovative lightweight construction materials that are already undergoing industrial tests were devised in recent years.

Using cellular metallic materials (CMM), it is not only possible to drastically cut mass and material, but also to predefine further characteristics depending on each application, which are in particular determined by material and cell structure: These are features such as sound absorption, heat insulation, energy absorption, mechanical damping, transmission of energy and substances or catalytic effects.

Manufacture

CMM can be manufactured from liquid, solid or gaseous phases. So far, the highest technological level has been achieved by metallurgical and powder metallurgical techniques. However, many of those methods are still under development. At present, we at Fraunhofer IFAM Dresden are exploring six techniques to manufacture CMM:

- Metallic fiber structures
- Metallic hollow sphere structures
- Open-cell PM foams
- 3D direct printed structures
- 3D wire structures
- Porous metal paper

METALLIC FIBER STRUCTURES

Fraunhofer IFAM Dresden has years of experience in manufacturing cellular metallic materials from sintered metallic short fibers for a wide variety of applications. To generate these materials, we use, for example, unique metallic fibers produced with our in-house melt extraction technique. Using this technology, high-efficiency metallic fibers are created directly from the melt. The procedure makes it possible to use the advantages of rapid solidification for targeted optimisation of parameters and to offer entirely new fibrous materials. The fibers manufactured are further processed by a special technology and sintered to highly porous structures afterwards.

Applications

Highly porous fiber structures can be used in many ways, for instance for

- Filter elements, hot gas filtration, diesel soot filters
- Catalytic converters and catalytic converter carrier materials
- Sound absorption and heat insulation at high temperatures
- Heat exchangers and heat regenerators
- Abradable sealings
- Electrode materials
- Porous burners

METALLIC HOLLOW SPHERE STRUCTURES

Cellular structures formed out of single cells are produced in a specific way as metallic hollow spheres. In comparison to other cellular metallic materials, their structural properties are highly reproducible.

Characteristics

Hollow sphere structures are very flexible in terms of geometry and material selection. Consequently, it is possible to adjust both structural and functional characteristics according to specific requirements.

Hollow sphere structures are characterised by

- Extremely low structural density (up to 97 % porosity)
- Excellent and easy-to-control energy absorption capability
- Low heat conductivity (about 1 % of the basic material)
- High mechanical damping capacity
- Excellent sound absorption

1 *Porous burner - fiber structure,* 2 *Phase change heat storage device with fiber structures,*
3 *Lightweight construction sandwich element with metal hollow spheres*

Hollow sphere structures typically have cell diameters from 1.5 to 10 mm with cell wall thickness values from 20 to 500 µm. It is also possible to produce panels, tubes, cylinders, net-shape components and hollow sphere sandwich structures from metallic hollow spheres.

Applications

Hollow sphere structures can be used in a wide range of applications in the automobile industry – for energy and sound absorption, in mechanical and equipment engineering to reduce weight, for damping and sound absorption. In the chemical industry and in environmental technology, they are applied as catalysts, while in the field of biomaterials their adaptable mechanical characteristics are valuable in combination with consistent lightweight construction.

OPEN-CELL PM FOAMS

Open-cell metal foams are lightweight, ductile and perfusable materials with extraordinary application potential. Due to the use of the powder metallurgy production route, open-cell foams can be manufactured from almost all metal powders suitable for sintering.

Characteristics

Open-cell foams are characterised by high permeability, a large specific surface area and good formability. Assuming that a suitable material is used, it is possible to fabricate foams that withstand extreme corrosion and oxidation. Due to their structure, which conforms to that of the body, open-porous metals are lending themselves for growing in of bone cells.

Applications

Functional applications, e.g. filters, sound absorbers, catalyst carriers, heat exchangers, flame arresters and porous burners, as well as electrodes are appropriate due to the open cellular structure. Moreover, in the medical range, the material is designated as bone substitute.

3D DIRECT PRINTED STRUCTURES

Cellular direct printed structures offer the advantages of a printing technology suitable for mass production together with the structuring opportunities of classical additive layer manufacturing. This makes it possible to manufacture small precise microstructure parts in large quantities at low cost.

With optional changing of the screen, it is possible to vary the structure of every printed layer. This procedure enables the manufacturing of various different parts simultaneously.

Characteristics

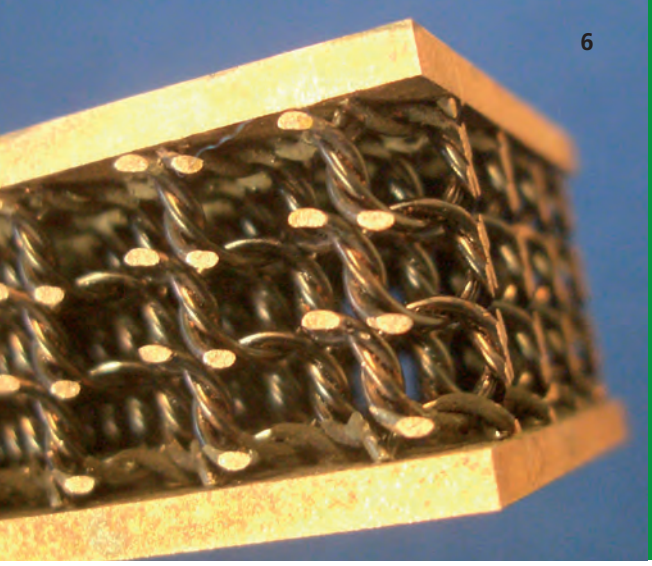
It is possible to manufacture sintered direct printed structures with a web width of about 100 µm with channel widths of approximately 50 … 80 µm. The maximum component height amounts to a few centimeters. Contours may be maintained up to about 3 µm accuracy. With this technique, closed cavities without an additional joining step can be manufactured. Thanks to a process based on powder metallurgy, structures from almost all sinterable metal powders can be produced.

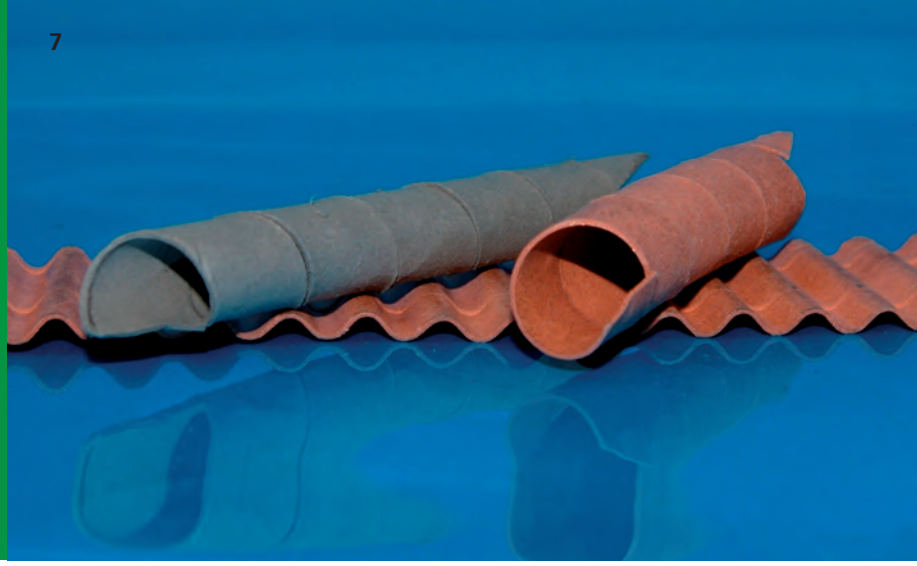
Applications

3D direct printing can be used to manufacture innovative components that have been regarded as unproducible up to now.

- Heat exchangers and heat regenerators
- Micro process engineering
- Mechanically optimised structures
- Catalysts and catalyst carriers
- Fuel cell technology
- Abradable sealings
- Jewellery and decoration
- Insulating and dampening elements
- Medical devices
- Medical implants

4 *Open-cell structure in a particulate oxidation converter,*
5 *3D direct typed structure, sample*





3D WIRE STRUCTURES

Three-dimensional wire structures are an entirely new variant for cellular metallic materials. These are open, periodical cell structures.

Characteristics

Due to great flexibility in the selection of the material (e.g. Fe-, Ni-, Cu-, Al-, Ti based materials), the wire diameter and the adjustable cell size (e.g. from 3 to 25 mm), it is possible to adjust the structural density values in a defined manner and wide range down to 0.05 g/cm³. 3D wire structures are characterised by excellent specific mechanical characteristics, low heat conductivity and a great capacity to absorb deformation energy. Another advantage is the excellent reproducibility of the mechanical properties.

Applications

3D wire structures may be used as components for reinforcement, e.g. for lightweight construction or castings subjected to high loads. Other potential applications are heat exchangers, explosion protection and biomedicine. Additionally, these structures can be used in container production or as multifunctional lightweight construction elements in civil engineering.

POROUS METAL PAPER

Fraunhofer IFAM Dresden in cooperation with the Papiertechnische Stiftung PTS has developed the so-called Porous Metal Paper, an innovative route for the manufacturing of highly porous thin foils and sheets.

Characteristics

The manufacturing of Porous Metal Papers is based on a well established basic process. It allows for the flexible selection of basic materials and is adjustable in pore size and porosity. In addition to its easy shaping, Metal Porous Paper is highly reproducible and suitable for mass production at low processing costs. The Porous Metal Paper is characterised by an excellent mechanical stability. Furthermore, filtration tests have shown its extraordinary filtration capability and efficiency up to temperatures of about 800 °C.

Applications

Porous Metal Paper can be implemented in manifold applications such as filters and membranes, electrodes, surface burners, vaporizers and evaporators. In addition, it is conceivable to use them as electromagnetic shielding, heat exchangers and heat pipes, thermal insulation as well as catalytic converter and converter substrates.

R&D SERVICES

- Application oriented studies related to materials and manufacturing solutions for a specific customer problem
- Development and manufacture of structures
- Design of complex components
- Manufacture of prototypes and small batches
- Simulation of flow and heat conduction characteristics

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6 *Sandwich structure with 3D wire structures,* 7 *Samples of porous metal papers*