CELLMETNEWS I-2010

EDITORIAL

Dear reader,

Since the last *CELLMET News*, the most important event within the cellular metals community was the *MetFoam 2009* which took place from September 1 till 4, 2009, in Bratislava, Slovakia. Despite the world wide economic crisis, more than 150 participants from around the world were discussing the latest results in manufacturing, properties and applications of cellular metals and alloys. In some areas, progress could be pointed out, like modelling, structural analysis, foam physics and stabilisation. Furthermore, a strong engagement in cellular metals for biomedical applications could be observed. A warm *Thank you* to Fero Simancik and his team for organizing the excellent MetFoam 2009.

In this issue of *CELLMET News*, we will highlight some of the latest developments in the sphere of cellular metals.For instance, a new Al-foam and a metafoam composite for cargo vessels, an absorption cooling demonstrator with Al-fiber structures and a new lotus metal heat sink will be addressed. Additionally, an innovative way to manufacture s.c. auxetic cellulars and a new metal foam composite will be presented. Two companies will inform about the latest progress in manufacturing Al-foam and metal hollow sphere products.

The next major event on cellular metals will be presented at the end of this year. An international conference on cellular materials – **CELLMAT 2010** – will be held in Dresden from October 27 until 29, 2010. The aim of **CELLMAT 2010** is to support and promote the application and related topics of cellular materials especially. Compared to the last CELLMET conferences, not only metals but also ceramics and glasses will be included, thus offering more opportunities for the end users of cellular materials and broadening the knowledge for all of us dealing with cellular structures.

I invite you to join the **CELLMAT 2010** and share your experiences in cellular materials.

Günter Stephani
Fraunhofer IFAM Dresden

Chairman CELLMAT2010

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Alcoa Aluminum Foam

The low density aluminum foam product developed at Alcoa Technical Center can now be manufactured at commercial production rates of 1,500 kg/hour. The product is continuously cast as a wide, thin plate and cut to length for applications in the architectural, transportation and defense sectors. Through the controlled decomposition of carbonate powders within a molten aluminum-magnesium alloy, a stable, foamable suspension is created. This suspension allows for production of aluminum foam with a relative density as low as 25% of the parent alloy, and resists both coalescence and drainage. The panels are currently being tested in both the laminated and unlaminated condition for use in architectural applications. Corrosion resistance in the coated and uncoated conditions has now been characterized following one year exposures to high humidity and salt water environments. As the fine cell size allows for screw fastening, various screw geometries and materials are being tested under simulated service exposures.

Density	*Minimum*	*Maximum*	*Average*	*Units*
Gauge	18.4	19.7	**19.0**	mm
Gauge Variance	-	2.5	**0.64**	mm
Bow	-	1.65	**0.48**	mm
Width	912	917	**914**	mm
Length	2436	2441	**2438**	mm
Panel Solid Fraction	26%	32%	**29%**	%
Panel Area Weight	13.3	16.4	**15.0**	Kg/m^2
Panel Weight	30	37	**33**	Kg
Compressional Strength	9.7	16.6	**13**	MPa
Bend Rupture Strength	9.7	16.6	**13**	MPa
UTS	5.5	11.7	**6.9**	MPa
Comp. Modulus	3.5	4.8	**4.1**	Gpa
Tensile Modulus	3.5	4.8	**4.1**	GPa
Bend Modulus	3.5	4.8	**4.1**	GPa

Figure 1: Specification properties for Alcoa Aluminium Foam (19 mm).

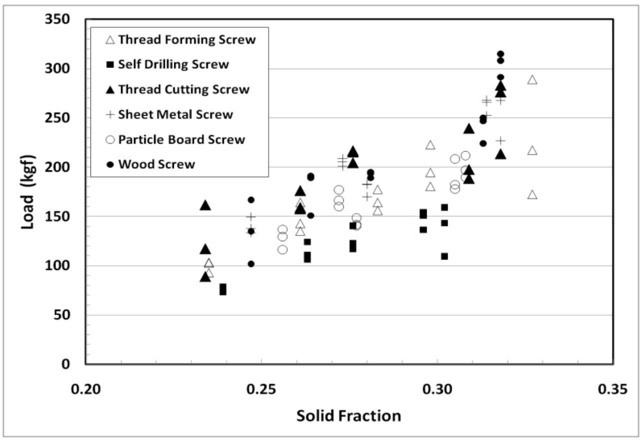

Figure 1: Screw pull-out strengths for six different screw types in Alcoa Aluminum Foam. Standard wood screws and thread forming screws offer the highest pull-out strengths.

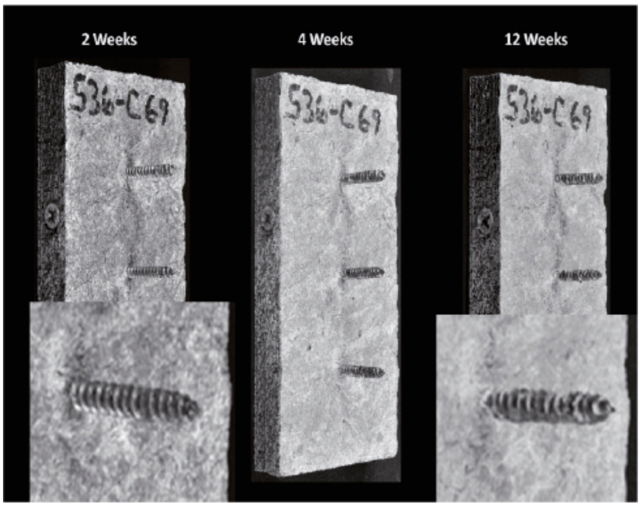

Figure 2: While strength loss was minimal, use of galvanized screws with aluminum foam resulted in corrosion build-up. Stainless steel or aluminum screws are recommended in outdoor applications.

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Functional ceramic coatings for cellular metals

Cellular metals such as metallic hollow spheres structures, single hollow spheres and open celled metallic foams are lightweight, ductile materials with an enormous application potential. Coatings to functionalize and protect the surfaces of the cellular metals offer many novel application areas for such materials.
In contrast to the established PVD and CVD methods, the coatings will be performed in a wet chemical process using commercially available inorganic polymers like polysiloxanes and polysilazanes or sol/gel-suspensions as starting substances to form thermoset or ceramic coatings on cellular metals. The coatings were synthesised by Liquid Phase Deposition (LPD), such as dip- and spray coating. This alternative low cost method, well known from the lacquer technology, allows the coating of bigger parts with difficult geometry.

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Subsequent thermal treatment of the as coated materials provided a thermoset or ceramic coating under good reproducible conditions.
The application of filler systems increases the functionality and the performance of the as synthesised coatings.
In principal, two different kinds of coatings can be obtained by this process: thin, dense thermoset or ceramic coatings or highly porous ceramic coatings with tuneable pore size, form and volume. Diffusion of elements from the coating into the substrate during thermal treatment leads to the formation of an interface layer, the reason for the excellent adhesion of the coatings on the substrate.
The broad field of applications of such functionalised cellular metallic materials comprises oxidation and corrosion protection, catalysis, adsorption materials for gas cleaning, medical applications, and materials for the biotechnological and chemical process engineering. Figure 1 shows one example for such applications.

Figure 1: Dip-Coating on metal fiber structure.

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Titanium with bioanalogous structure for use in orthopaedic implants

Bone- and bone/ cartilage defects are a major problem in medicine. These lesions have to be replaced in a stable manner, until the bone produced naturally in the body is able to regain its mechanical function autonomously. Typically, defects like these are at present replaced with bone produced naturally in the body or with solid bone replacement material, which both carry numerous risks.

In comparison, cellular metallic materials are less stiff due to their porous structure. This value typically falls within the stiffness range of a cancellous bone. Such cancellous bone is understood as the juxtaarticular (situated in the vicinity of a joint), a highly porous structure of the bone at the bone's end, which is frequently subjected to a damage fracture, in particular in osteoporosis patients. Open-porous metals enable bone cells and blood vessels, which are absolutely necessary for bone growth, to be incorporated. Moreover, the strength of these materials may also be compared with that of bones. The great interest of medical research in such materials arises from these properties.

Open-porous foams out of the titanium alloy Ti6Al4V have been developed in a co-operative effort between the Fraunhofer institutes IFAM and IKTS. These materials are produced by means of a powder metallurgical replication technology, in which reticulated polyurethane foams are used as a template for the cellular structure. In this process, very homogeneous foam-like structures with an adjustable density of 0.7 – 1.0 g/cm^3 are formed. The mechanical properties of the bone replacement material can be specially adapted to the corresponding values of the bone through a targeted manipulation of the material's density and structure. Specifically, this technology makes possible an individual adaptation to the state of the surrounding bone material. This way, the material may be adjusted to fit either into an adolescent bone or an older, osteoporotic bone.

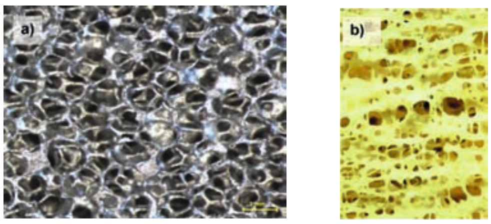

Figure 1: Cell structure of open cell titanium foam (Figure a) and structure of a healthy spongious bone (Figure b, courtesy of rs media GmbH).

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This innovative material with its fascinating properties is analysed in an interdisciplinary project; funded by the Federal Ministry for Science (BMWi), the Fraunhofer institutes co-operate with their industrial partners and the university hospital of Dresden to explore the production technology as well as biological and medical aspects of engineering up to the application in the animal model. The new implant material has been incorporated as a replacement for vertebral bodies in sheep. The first tests with permanent implants demonstrated an outstanding in-growth of bone cells into the material even for larger distances. The good osteoconductivity of titanium also argues in favour of its use as an endoprosthesis.

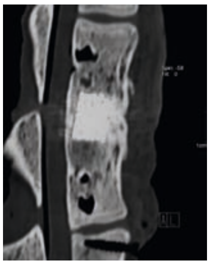
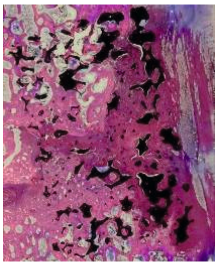


Figure 2: X-ray picture of a metallic foam as vertebral body replacement (left side) and histology of the bone ingrowth into the metallic foam (right side).



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Aluminum foam and plastic composites for cargo vessels

In April 2009, the MARTEC ERA-NET Project „ULIVES – Ultralight Materials For Ice Going Cargo Vessels" started. The project consortium includes three German and two Finnish partners.
It contains the areas of lightweight engineering, development and manufacture of aluminum foam and plastics components up to the development of whole vessels, including the required test methods. The development of a new type of inland area cargo vessel is the aim of the project. By consistent use of modern design concepts and new lightweight materials, the ship weight will be drastically reduced compared to conventional solutions. Simultaneously, an increasing payload and, thus, raising transport efficiency will be realized.
Conventional ice-going inland area cargo ships got a transport load of around 3,000 tons at an own weight of 850 to 1,000 tons. The intention of the project is to reduce the weight of the vessel down to 500 tons at a payload of about 2,900 tons. This excellent payload/mass ratio will be unique in the cargo shipping. As final result, a ship built the proposed way could avoid transports of about 55 to 60 trucks.
The specific characteristic of the project is that the investigations are superficially based on ice-going ships. That is why for stability especially the hull of the ship up to about 70 cm above the water line is still made of steel.

All wall constructions above, superstructures and interiors are included in the considerations for structures made of aluminum foam and reinforced plastics.

The development, production and consistent application of new material concepts based on aluminium foam and the use of innovative plastic composites constitutes a guarantee for a low specific weight and high rigidity. For a successful establishment and application of the new material concepts in the cargo shipbuilding, the enlargement of the realizable component dimensions towards planar dimensions up to 5000 x 1000 mm^2 is one essential part of the project.

Source: Laffcomp Oy.

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Latest Developments: hollow spheres and metal foams become products

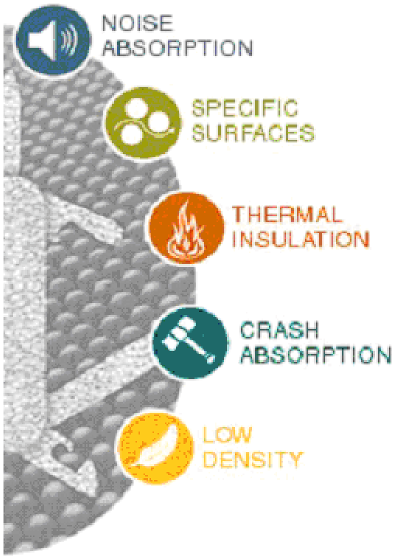
Hollomet GmbH produces metallic hollow spheres, metallic hollow sphere structures and open celled metal foams for a wide scope of industrial applications.

Within the last 10 years, Glatt Systemtechnik GmbH and the Fraunhofer Institute for Manufacturing and Advanced Materials IFAM, both based in Dresden, developed new approaches, tailored to meet market needs in cellular materials: multifunctional metallic (and ceramic) hollow spheres and highly specialized metal foams. Both manufacturing processes are based on a combination of expertise in powder metallurgy and special process technology. Hollomet GmbH, Dresden/Germany was founded in 2009 to use and combine several national and international research activities in order to provide solutions for demanding industries.
The target of hollomet is to offer products to the industry which are produced under economical conditions. Contracts with different partners have been signed for development and production of cellular materials. It has been proven that, depending on the requirements of our partners, we can offer compatible prices.
Hollomet addresses different markets with its three brands:

- **globomet** stands for metallic hollow spheres and structures,
- **globocer** for ceramic solutions and
- **foamet** labels open cell metallic foams

Additionally, each brand represents a specific product; they are used in a wide scope of industries:
Foamet is a metallic foam, manufacturable from nearly every sinterable material. Foamet is commercially available with a surface area of up to 3,500m^2 per m^3. This surface area can even be increased through a subsequent surface treatment. Foamet is used for many purposes, e.g. as heat exchanger in medical devices where high heat transfer rates and high stability are required. An automotive supplier uses Foamet for exhaust air treatment and a major chemical company uses the product at medium size reactors for fuel production using Fischer-Tropsch processes.
Globomet is a highly multifunctional product combining low mass and high stability. It is widely used in many applications, e.g. for a heat and dirt resistant sound absorber. Other companies use Globomet to manufacture ultra light crashboxes or lightweight machine parts with a superior damping behavior.

Designers like hollomet too, making lampshades, claddings and furniture. Rapid prototyping specialists use the product for filling moulds in order to produce cheap ultra light und ultra stable parts.
Globocer is used for ceramic and zeolith absorbers, e.g. as filters and for air separation. Other customers use it as an inert and highly reproducible catalyst carrier, reducing the amount of catalyst needed.
All brands and products have one thing in common: their cutting edge multi-functionality. Hollomet's products offer a combination of demanded characteristics in only one component, thereby decreasing costs and increasing efficiency.
Due to our experienced R&D team, a close relationship with the Glatt Group and the IPC Process Center as well as a broad network into different industries, universities and internationally respected research institutes, we provide expertise and insight into different industries, delivering not only products, but solutions.



Bibliography:
- Further information on products, brands and applications can be found at http://www.hollomet.com
- A general overview as well as information on the latest research projects can be found in Öchsner/Augustin: Metallic Hollow Sphere Structures. Manufacturing, Properties and Applications, Springer 2009 (incl. Bibliography)

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Microporous syntactic foams for high compression loads

The Fraunhofer Institute for Manufacturing and Applied Materials IFAM Bremen specialises in the development of syntactic foams based on metal matrices with integrated glass or ceramic micro bubbles. For the production a variety of technologies can be applied, e.g. aluminium and zinc melt infiltration of sintered micro-bubble-preforms by means of squeeze casting or by metal injection moulding (MIM) of iron and steel powders mixed with glass or ceramic micro bubbles. MIM is of special interest as a near-net-shape-technology which allows the series production of small and complex-shaped components with adapted metal matrix material.
Due to their special structure, syntactic foams exhibit relative densities which are higher in comparison to other foam structures. The resulting compression strengths are, however, still higher than the density-strength-correlationship models would let expect, a fact which is caused by the complex interplay of matrix and integrated hollow spheres. The syntactic foams have strictly closed-cell porosity, can be coated and are tight against fluids even at elevated pressures. Furthermore, using special production techniques like 2-component-MIM or special preforms gradient structures of syntactic foams and composites with other materials can be produced.
Based on their property spectrum, the target applications of the materials are:

- absorption of crash energy with high energy load densities
- density adapted light-weight structures or
- materials for ultra-sonic equipment for harsh environments

In the framework of a joint German-Egypt cooperation project, the technology is currently being pushed forward to the production of larger components and components with high-alloyed corrosion resistant steel alloys.

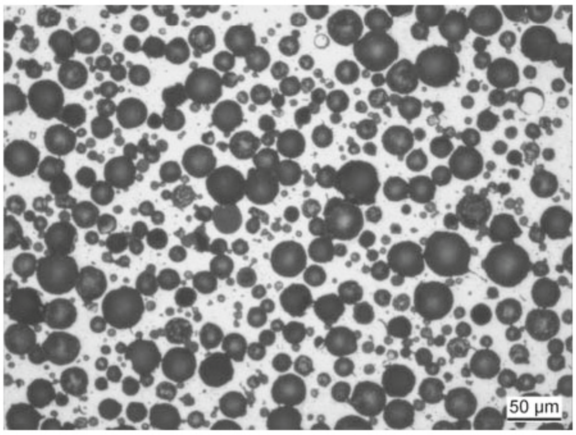

Figure 1: Metallographic section of Fe+10wt% S60SH syntactic foam.

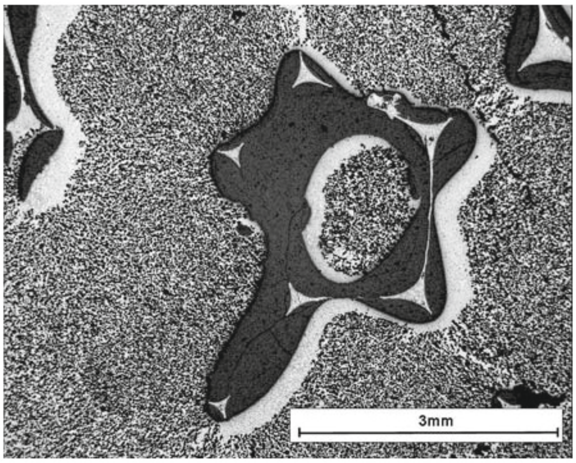

Figure 2: Metallographic section of glass bubble structure with integrated Al2O3-sponge after infiltration.

Property (selection)	Material (selection)	
	aluminium, S60HS micro glass bubbles melt infiltrated	iron (99%) + 5wt% S60SH micro glass bubbles
Density [g/cm^3]	1.2-1.4	~5
Mean pore size [µm]	35	35
Compression strength (10%) [MPa]	150-250	300
Energy absorption [MJ/Mg]	~75	~30
Young´s modulus [GPa]	~20	~100

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A highly flexible substrate for cost-effective particulate filters with effective deposition rates

With iron and nickel-based alloy metal foams, Alantum Europe GmbH offers a substrate that opens up entirely new possibilities for the manufacturing of diesel particulate filters (DPF), especially for commercial and off-road vehicles. The good ductility and high flexibility of the 100% open-pore material allows the DPF design to be determined freely. Different porosities make it possible to define the level of deep bed filtration in the system. Simple canning without filter beds and integrated DOC/DPF properties also provide economic benefits.

High temperature and corrosion resistance, coupled with a very good soot storage capacity, are among the basic requirements of an effective substrate for diesel particulate filters. The iron and nickel-based alloy metal foams from Alantum Europe GmbH achieve these properties thanks to a patented, stable, and continuous production process. During this process, metal foams are coated and thermally treated with a high-alloy metal powder that is tailored to the particular application and design (Fig. 1). Fusion takes place, contributing to an extreme enlargement of the specific surface of the light metal foam and resulting in a good filter effect. At the same time, the temperature resistance of the thermal conductive alloy foam increases up to 1,000 °C. The composition of the alloy can be modified and customized within a broad range thanks to the production process and also enables various properties of the alloy foam to be adapted to meet specific customer requirements.

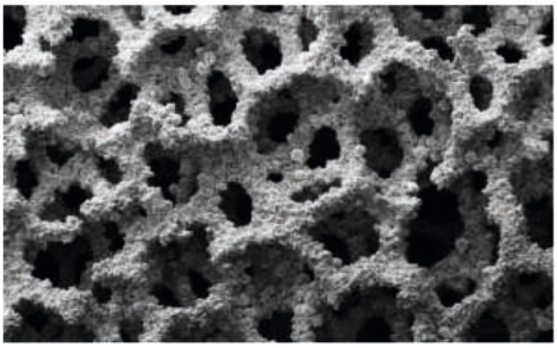

Figure 1: Metal powder coated iron-based foam.

In contrast to current market standard substrates, the homogenous alloy foam remains flexible, ductile, and can be cut at any length, allowing it to be rolled, stacked, bent, and shaped, for example. It is also possible to sinter the material, usually manufactured as sheets, into stacks during the production process and to subsequently cut them. Even very complex structures can be manufactured in this way.

Figure 2: Diesel particle filter system based on open pore foam.

The 100% open pore substrate has a very permeable structure with a large specific surface area, on which the particles can be deposited. As the material can also be heated inductively, regeneration can also be carried out contact-free: in off-road vehicles, diesel locomotives, and stationary diesel engines.
As one result, a certified DPF system is in use with Alantum's alloy metal foam to reduce the pollutant category of heavy duty trucks from EURO III to EURO IV (Fig. 2).

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Cellular Metallic Materials – networking from idea to innovation

About four years ago, the network Cellular Metallic Materials has been initiated aimed at the intensification and cooperation support of companies interested in the field of cellular metallic materials.
The cooperating network partners are operating in various areas. The further development and manufacture of cellular materials, material analysis, engineering, commercial vehicle, building industry, casting and forming by rolling or extrusion belong to these areas. Networking enables the partners to manage very complex tasks and projects, helps by sharing resources and is thus highly effective and reduces costs.
In the initial phase, the network has been funded by the Federal Ministry of Economics and Technology within the sponsor contest "Netzwerkmanagement-Ost (NEMO)". In the meantime, the network has become economically independent.
The activities of the current 13 network partners are focused onto the initiation and implementation of research projects. In these individual and joint projects, the partners deal with current material and technology themes aimed at the further development of cellular metals, the production cost reduction and the start up of marketable applications.
The project ideas are multifaceted concerning not only conventional areas like the machine tool building but also the shipbuilding and construction engineering.

In the near future, a transnational joint research project with the title "Multibau" will start supported by the Sächsische Aufbaubank (SAB) and the Investment Bank Saxony-Anhalt. Main objective of the project is the development of new multifunctional light weight construction solutions by utilization of specific cellular metals properties. That is one way to provide approaches for the building industry fulfilling the current complex requirements. Heat storage and insulation, climate control, electromagnetic field protection, weight and fire prevention especially are demands onto the construction.
In particular, they are looking for multifunctional solutions such as light building boards with integrated cooling and heating function and dividing wall elements for offices and industrial buildings with integrated fire and noise protection.
Possible applications are office, floor and hall construction, floor addition, living container buildings and temporary buildings.
The following picture shows an example for the use of aluminium foam in the building industry. Lightweight aluminium foam panels with rod-steel mesh in the boundary areas have been developed by a consortium of project partners. The shown balcony demonstrator has been built for demonstration purpose. Some of the engaged project partners are members of a network consortium. Financially, the project was funded by the SAB (project 12425/2026).
The developed balcony panels are a pure lightweight solution. Advanced features such as heating and cooling, which are part of the project Multibau, have not been covered by the project.

Figure 1: Example for application of cellular metals in building industry: Demonstrator balcony platform Structure: Panels made of aluminum foam-steel with rod-steel mesh in the boundary areas (Stahlbau Seerhausen GmbH, Drahtweberei Pausa GmbH, Sächsisches Textilforschungsinstitut e.V., Fraunhofer IWU) and mineral coating.

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Open-porous aluminium structures for high power-density adsorption cooling

Today, the cooling market (air conditioning, refrigerators) is dominated by mechanically driven compression devices. Within the framework of an internal Fraunhofer development project, several institutes (IFAM, ISE, ITWM, IVV) laid focus on an alternative technology that allows cooling by means of waste and solar heat: adsorption cooling. Up to now, adsorption cooling devices had a quite low power density and, consequently, were too large to be applied for mobile applications like air conditioning of cars. Therefore, the goal of the project was to drastically improve the power density of adsorption devices without reducing efficiency.
The central module of adsorption refrigerators is the adsorber, were the evaporation and the condensation of the cooling solvent takes place. In order to reach the project goal of a power density of at least 100 W/l which is twenty times better than the current state-of-the-art. In order to reach this ambitious goal, the adsorber structure must possess a high heat conductivity. At the same time, it should provide a very high specific surface area that can be covered with a thin layer of the sorbent.
Open porous aluminium foams (sponges) or fibre structures offer the combination of exclusive functional characteristics like excellent permeability for fluids and gases, high heat conductivity and the required large specific surface area. These structures can be coated completely with adsorbents and demonstrate sufficient strength for refrigerator design. All these properties build a brilliant fundament for innovative concepts for adsorption heat exchangers. For manufacturing of the aluminium sponges, a compact structure made of polystyrene granules is infiltrated with aluminium melt using a high-pressure-die-casting process. Owing to the configuration of the polystyrene placeholder granules, the process results in a pre-defined open porous structure with an open porosity between 60 and 85 %. Using the placeholder granules as a "negative" enables to design homogeneous or gradient structures in a defined manner.
For manufacturing of the aluminium fibres, crucible melt extraction is used. Highly porous components can be made from such fibers by suitable deposition and sintering methods.

The most promising approach to apply the adsorption material onto the aluminium heat exchanger structures is crystallization. The coating with zeolite was performed by a working group of the University of Erlangen and by the company Sortech AG. An example of a zeolite coated aluminium sponge is displayed in Fig. 1.

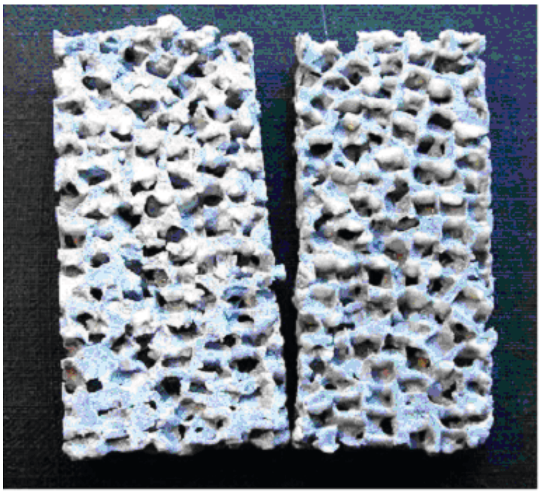

Figure 1: Zeolite-aluminium composites manufactured by space holder technology.

The coating results in a homogeneous, compact adsorbent layer. It offers a highly stable and adherent coating on the aluminium structure. Kinetic testing showed that both sponges and fiber structures are able to provide the necessary materials properties. Using the developed technology, a demonstrator (Fig. 2) is now being built in order to test the system performance and prove that a cooling power density of 100 W/l can be reached. Given the very encouraging results obtained so far, it is expected that such zeolite coated cellular structures will find application in air conditioning of passenger cars or in stationary retrofit cooling where space is limited.

Figure 2: Adsorption cooling demonstrator with aluminium fiber structures before coating.

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Development of Lotus Metal Heat Sink

In recent years, since heat dissipation rates in power devices and high frequency electronic devices have been increasing, the heat sinks with high heat transfer performance are required to cool these devices. Heat sinks utilizing microchannels with a channel diameter of several tens of microns are expected to provide excellent cooling performance because higher heat transfer capacity is obtained with smaller channel diameters. Therefore, porous materials with open pores are preferable for three-dimensional microchannels because of the higher surface area per unit volume and lower product cost. Various porous materials such as sintered porous metals, cellular metals and fibrous composites were investigated for heat sink applications. However, heat sinks using such porous materials were clarified to have a high pressure drop because the cooling air flow through the pores of the porous materials is complex. Among the porous materials, lotus-type porous metals with straight pores are preferable for heat sinks due to the small pressure drop of the cooling air flowing through the pores.
An outer view of Lotus/Gasar copper is shown in Fig.1.

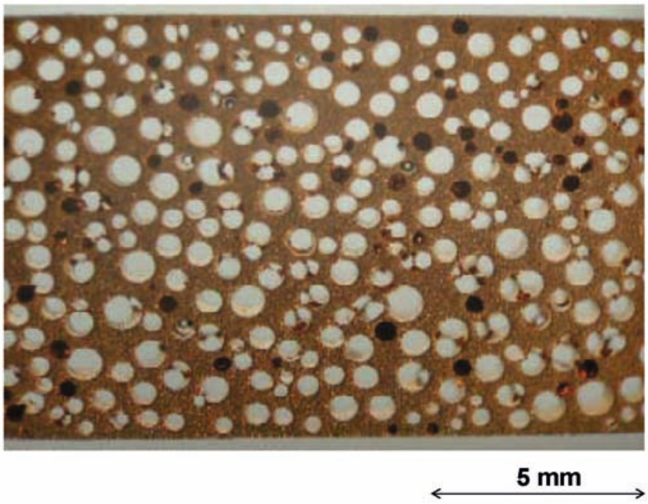

Figure 1: An outer view of cross-section of Lotus/Gasar copper perpendicular to the pore axis.

These metals with many straight pores are fabricated by unidirectional solidification of the melt dissolving hydrogen. Pressurized hydrogen gas was used for conventional fabrication method of Lotus/Gasar metals. However, we developed Thermal Decomposition Method (TDM); only pore-forming compounds are used without high pressure hydrogen. The fabrication technique of the Lotus metals through TDM exhibits low-cost performance with simple and safe procedures.

The heat sink consists of a series of three permeable lotus copper blocks with a thickness of 1 mm as shown in Fig. 2. Figure 3 shows the measured heat transfer coefficients as a function of the flow rate of air.
A very large heat transfer coefficient of 5000 W/(m2K) is shown under an inlet velocity of 1.0 m/s of blowing air, which is 13.2 times higher than that for the conventional groove fins. Thus, lotus metal heat sink exhibits high-performance and low cost, which is expected to be commercialized soon.

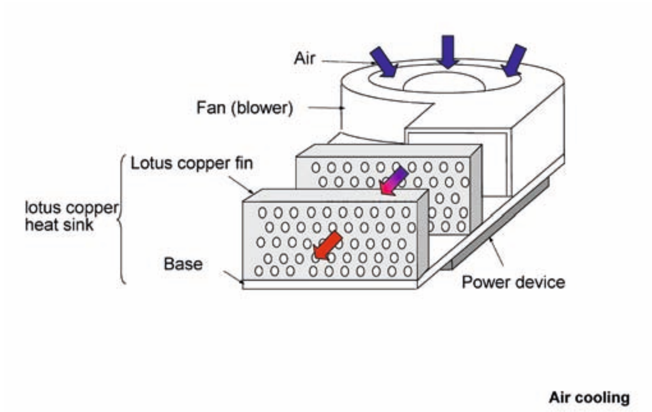

Figure 2: Lotus copper heat sink.

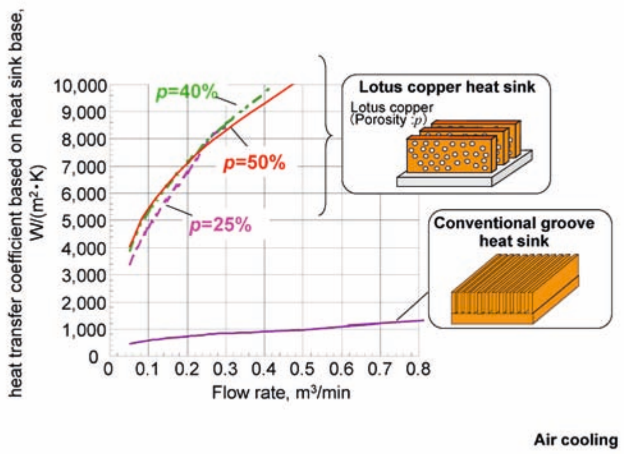

Figure 3: Flow rate dependence of heat transfer coefficients.

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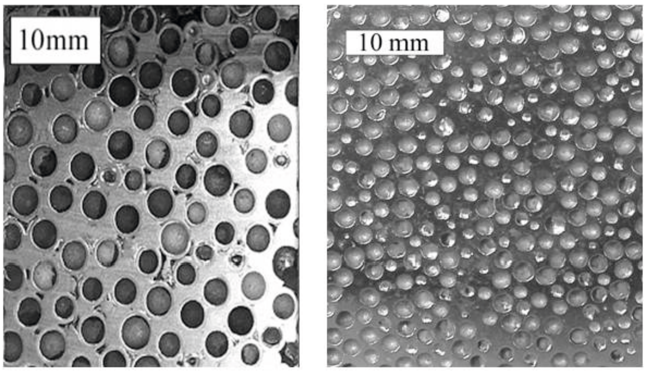
Composite metal foams, a new generation of foams from combining metal matrix composites and metallic foams

Composite metal foams (CMF) are a new class of metal foams created at North Carolina State University by combining the advantages of metal matrix composites and metallic foams. This new type of foam is processed either by existing gravity casting or powder metallurgy techniques. For cast foams, the matrix used possesses a lower melting point element than the spheres with a higher melting point element. This is to keep adequate difference in components melting points and maintaining the integrity of the steel spheres during the casting process. Powder metallurgy processed foams, on the other hand, use similar sphere and matrix materials. Properties of the foam (shown in Table 1) are controlled by such parameters as sphere and matrix materials, sphere size, sphere wall thickness, and the processing technique that can be modified to suit customer needs.

	Cast Foam	Powder Metallurgy Foam
Materials	Aluminum 356 matrix 316L SS spheres	316L SS matrix 316L SS spheres
Sphere outer diameter (mm)	3.7	2.0
Sphere wall thickness (mm)	0.2	0.1
Density (g/cm^3)	2.46	2.95
Relative Density (%)	42.7	37.5
Plateau Stress (MPa)	110	127
Densification Strain (%)	57	54
Plateau Strength/Density ratio	45	44
Energy Absorption (MJ/m^3)	53	68

Table 1: Properties of Composite Metal Foams processed by casting and powder metallurgy.



Al-steel Cast Foam

Steel-steel Powder Metallurgy Foam

Figure 1: Cross section of Al-steel cast foam and steel-steel powder metallurgy foam.

The high energy absorbing capability of CMF shows promise for many applications including crash bumpers for cars and ballistic protection armors. Excellent performance of CMF samples tested in monotonic compression, compression-compression fatigue, and bending indicate that the material is also promising in many structural applications. Figure 2 shows pictures of composite metal foam processed by powder metallurgy before and after being compressed to 80% strain, highlighting the remarkable energy absorbing capability of these materials. The Young's modulus of composite foams measured to be close to that of bone making. CMF is an excellent candidate for biomedical implants to prevent "stress shielding". It is notable that the CMF can be made of various metals such as titanium and combinations of different metals. The researchers at North Carolina State University are currently studying the properties of CMFs under high-speed impact and simulation of the properties using various modeling approaches.

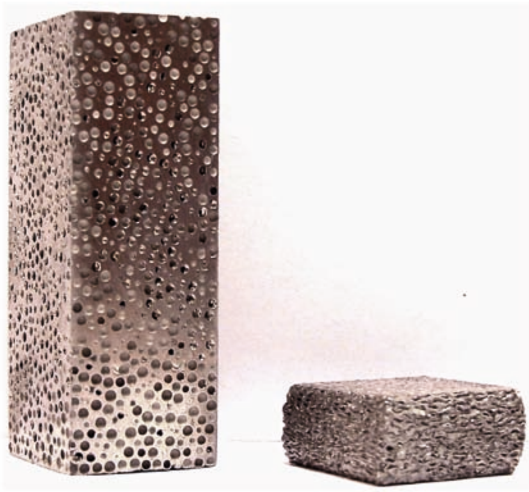


Figure 2: Stainless steel composite foam processed by powder metallurgy compresses up to 80% of its original size.

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Cooling of electronic devices by open pore metal foam

Performance, cost and reliability of advanced electronic devices are strongly impacted by the characteristic of their thermal management. To fully utilize the capabilities of such devices, there is a need to provide the thermal environment compatible with their requirements.
As a result, significant improvements have to be made in volume, weight and performance of these systems.

New materials like open pore metal foams have to satisfy the demands from emerging technologies like the high power light emitting devices (LED). Open pore metal foams are compared with standard heat exchangers to show their performance.

The heat transfer is governed by

$$\dot{Q} = k \cdot A \cdot \Delta T$$

The factor which could be influenced by the design most easily is the area of the exchanger. Other factors are limited by physical constraints.
The specific area density of the open pore foam is very high and has to be fitted to the thermal heat exchange process.

Experiments with LED
For demonstration, a 3 x 3 LED array (Fig.1) was used with a power of 11 W. The array is soldered on an aluminium plate of 50 mm in diameter and a thickness of 3 mm.

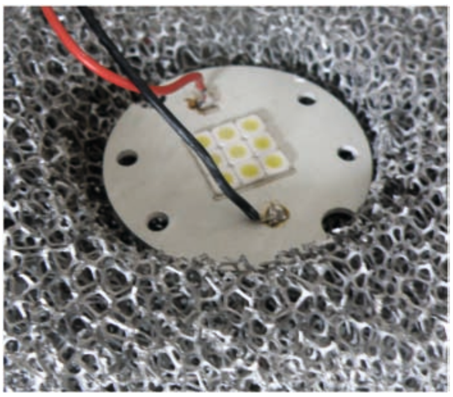

Figure 1: 10 ppi Al Foam with LED.

In this simple configuration, the temperature of the LED speeds up to 110 °C within seconds, which is very close to the working limit. In the next step, an aluminium extruded profil (height 30 mm, diameter 80 mm, weight 80 g and 12 fins) was used and the temperature was reduced to 60 °C. Cooling was only due to the free convection of air.

Different kinds of open pore metal foam heat exchangers were tested. Shape, pore size and material were changed. The resulting temperatures were within the range of 70 °C to 90 °C.

The best result was achieved by simply pressing the foam in the contact area of the LED plate (Fig. 1) and contact by a silicon panel to improve the contact between the Aluminium plate and the struts of the foam. The temperature which could be reached was 65 °C. Even with a high performance Cu heat exchanger of 250 g the temperature of the LED was 60 °C (black line, see Fig. 2). The limiting factor is the heat transfer through the air and could only be improved by using a fan.

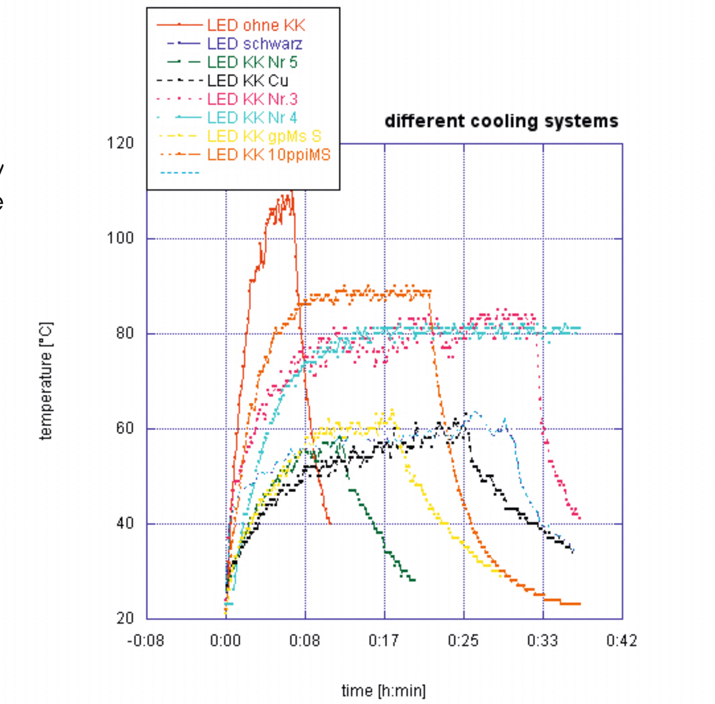

Figure 2: Temperature versus time for different cooling systems of LEDs.

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Changing the shape of the foam and testing with the thermal camera (Fig. 3) shows that the heat transfer in the foam is limited to about 20 mm. Oversized foam heat exchangers do not improve the heat transfer.

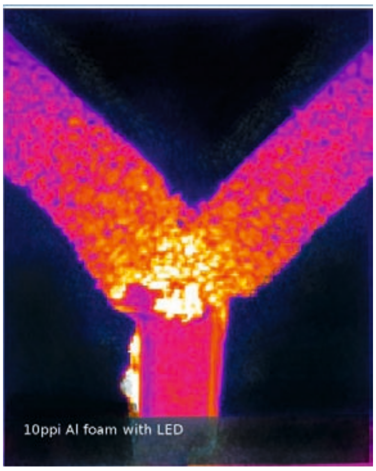

Figure 2: Temperature versus time for different cooling systems of LEDs.

Result

Open pore foams could be used for cooling high power electronic devices. For LED, the cooling effect could be combined with a design element of the lamp. The limiting factor is the heat transfer in the foam and should be kept in mind for the design process.

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Metal Foam: Research and Applications at University of Detroit Mercy

Research and application areas of metal foam at the University of Detroit Mercy are focused on fluid flow, thermal management and novel structural composites. The fluid flow empirical work involves studying the flow behavior in open-cell metal foam and determining the two key flow properties (the permeability and form drag coefficient) in both the Darcy and the Forchheimer regimes.
The thermal management thrust is concerned with analytical and experimental convection heat transfer studies employing aluminum foam for cooling of high-density electronics.

Another area under this thrust is to investigate the thermal conductivity enhancement of the phase change materials by embedding metal foam in them for thermal energy storage designs.

The structural composites area involves experimental and theoretical characterization of a new composite obtained by filling the open pores of metal foam with a polymer. The purpose of this composite is to provide enhancements over the polymer and to be employed where polymers are currently used. This thrust is in collaboration with Professor Nassif Rayess.

Metal foam research at the University of Detroit Mercy is funded by Ford Motor Company and Denso North America.

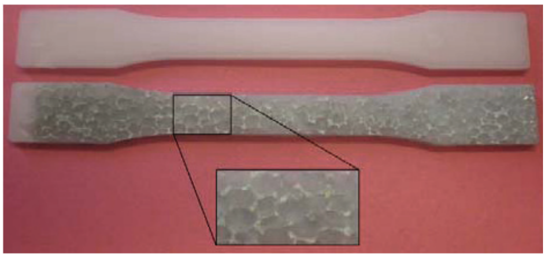

Figure 1: A polymer and a metal-foam-polymer composite tensile test sample.

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Accolade for Zincopor®

Review and explanation:

Zincopor® is a zinc foam with a closed surface, produced in pressure die casting (Fig. 1). The Zincopor® process is unique in the world and a development of Havelländische Zink-Druckguss GmbH & Co. KG (HZD).

Figure 1: Casing for leading pulleys cross-section.

The product launch took place at the end of 2008, after a development phase of about four years. With this method it is possible to reach dramatic weight and material savings (more than 55 % with ideal samples; more than 40 % with real components) with zinc pressure die cast products.
Typical processing possibilities like, for example, riveting or thread moulding are still possible. The special features of the closed surface (Fig. 2) allow for a polishing and electroplating exactly like with compact components. It is possible to use existing zinc pressure die cast tools; a remodelling or even new construction is not necessary.

Figure 2: Casing for leading pulleys cross-section enlarged.

Current developments:

During the two-yearly fair Euroguss, Europe's biggest fair for pressure die casting, a zinc pressure die casting competition is held regularly. Here, foundries can submit products which are assessed by selected experts of the pressure die casting industry according to two categories. The competition is so important because the audience of the Euroguss has a highly international character and is mostly made up of specialists.

At this year's challenge for zinc pressure die cast products, a Zincopor® cast product of HZD scored the first place in the second category: "Innovations and changeovers to zinc pressure die casting" (Fig. 3).

Figure 3: Casing for leading pulleys assembled.

The cast part submitted is a casing for leading pulleys of a high-value vacuum cleaner. In regard to the final product, the customer attached particular importance to highly stressable materials as well as outstanding visual appearance and surface feel; thus, several components which are usually produced from plastics were replaced by zinc pressure die cast products.
The secondary objective was to restrict costs and weight to a certain frame; that is why Zincopor® was used for producing the casings for leading pulleys.

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The reasons for the judgement of the experts read the following:
"Outstanding is the innovative casting technique which is applied to the casings for leading pulleys. The directed pore formation inside the component along with the concurrent optimal surface quality constitutes an innovative development in the sphere of pressure die casting. Consequently, a material saving and weight reduction of 25 % (author's note: which is a significant value given the relatively thin-walled components) could be achieved (author's note: in mass production).

Preview:

The pratical example described shows in an impressive way what is possible by using Zincopor®. We see the special potential in components which need a metallic visual appearance and surface feel, but which are inevitably overdimensioned because of a largely preset base geometry and size. This applies primarily to handles, cranks, knobs, holders, switcher, casings etc.

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ZINCOPOR®

Selective electron-beam melting: An innovative way to auxetic cellulars

Auxetic cellulars show the counterintuitive property of thickening under uni-axial tension and thinning under uni-axial compression. This negative Poisson ratio leads to exciting and new combinations of the mechanical properties such as low stiffness coupled with high shear strength and exceptional penetration resistance, which make these celluar structures promising candidates for numerous applications (e.g. impact protection structures or fastener systems).

Through recent work at the University of Erlangen, periodic auxetic structures (Poisson ratio of up to -0.4) can now be produced from Ti-6Al-4V in a highly controlled manner using selective electron-beam melting (Fig. 1), a generative method allowing for the generation of arbitrary geometries from metal-powder. This approach gives an exceptional degree of control over the mechanical properties by geometry control and also makes graded and combined structures relatively easy to achieve.

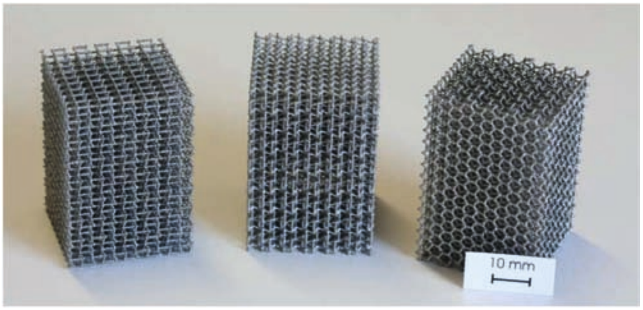

Figure 1: Auxetic cellular structures based on Ti-6Al-4V.

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ENGINEERING OF ADVANCED MATERIALS

CELLMAT 2010 - Conference will be held in Dresden

The third International Conference on Cellular Materials for Structural and Functional Applications will be held in Dresden, Germany, from October 27 until 29, 2010.
The aim of the conference is to support and promote the applications of cellular materials based on metals, ceramics and glasses.
At present, more than 100 contributions have been sent to the organising committee. In reviewing the abstracts, it becomes apparent that a broad range of application related papers, such as for automotive, machine tool, aerospace, acoustics, machine tool, biomedical and environmental have been handed in.
An exhibition of cellular materials and related topics will be organised during the event. Furthermore, an extended poster show including a short oral poster presentation will be offered.
The **CELLMAT 2010** will be organized by the Deutsche Gesellschaft für Materialkunde e.V. in collaboration with the Fraunhofer Institutes IFAM Dresden and IWU Chemnitz.

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CELLMAT2010

CELLMATAWARD2010

CELLMAT Awards for Excellence in Cellular Materials

Cellular Materials have gained increasing interest in the last decade due to their unique combination of properties like low weight, high specific stiffness, their energy absorption as well as their damping and insulating properties.
The **CELLMAT Awards** are granted to excellent results in the application (serial parts/demonstrators) of cellular materials.
Two awards will be launched:

- Award based on cellular metals
- Award based on cellular ceramics/glasses

Applications shall contain an explanatory statement of maximum 2 pages of the candidate. They should include evidence of:
- description of the part, technical data, field of application
- innovation compared to the state of the art, economic and ecological benefits
- a part, prototype, demonstrator has to be sent to the judging committee

Selection and notification of the **CELLMAT Awards** will be carried out by the Award Committee consisting of international representatives of industrial and academia experts in the field of cellular materials. The **CELLMAT Awards** will be presented during the conference **CELLMAT 2010**, which will be held from October 27 until 29, 2010 at the International Congress Center, Dresden, Germany.

The submission deadline for the CELLMAT Award is August 31th, 2010.

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Welcome to CELLMAT 2010 in Dresden

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