

Description

Image



Caption

1. Close-up of the material. © Chris Lefteri 2. Samples of foamed aluminum with various facing materials. © Chris Lefteri

The material

Metal foams are a new class of material, as yet imperfectly characterized but with alluring properties. They are light and stiff; they have good energy-absorbing characteristics (making them good for crash protection and packaging) and attractive heat-transfer properties (used to cool electronic equipment and as heat-exchangers in engines. Some have open cells, very much like polymer foams but with metallic characteristics (ductility, electrical conductivity, weldability and so forth). Others have closed cells, like "metallic cork". They are visually appealing, suggesting their use in architecture and interior design. At this point in time there are some 12 suppliers marketing a range of metal foams, mostly based aluminum, but other metals - copper, nickel, stainless steel and titanium - can be foamed. The data listed here are for a typical aluminum-based foam.

Composition (summary)

Most are based on Al with additions of Ca, SiC or Al₂O₃.

General properties

Density	15	-	30	lb/ft ³
Price	* 5.2	-	5.72	USD/lb
Date first used	1956			

Mechanical properties

Young's modulus	0.0653	-	0.174	10 ⁶ psi
Shear modulus	* 0.029	-	0.087	10 ⁶ psi
Bulk modulus	* 0.0653	-	0.174	10 ⁶ psi
Poisson's ratio	* 0.28	-	0.3	
Yield strength (elastic limit)	0.102	-	0.29	ksi
Tensile strength	0.102	-	0.363	ksi
Compressive strength	0.123	-	0.725	ksi
Elongation	1	-	4	% strain
Hardness - Vickers	0.045	-	0.12	HV
Fatigue strength at 10 ⁷ cycles	* 0.029	-	0.087	ksi
Fracture toughness	0.546	-	1.09	ksi.in ^{0.5}
Mechanical loss coefficient (tan delta)	* 0.005	-	0.04	

Thermal properties

Melting point	1.02e3	-	1.14e3	°F
Maximum service temperature	* 284	-	374	°F

Minimum service temperature	-459	°F
Thermal conductor or insulator?	Poor conductor	
Thermal conductivity	2.2 - 4.04	BTU.ft/h.ft^2.F
Specific heat capacity	0.217 - 0.229	BTU/lb.°F
Thermal expansion coefficient	10.6 - 11.7	µstrain/°F

Electrical properties

Electrical conductor or insulator?	Good conductor	
Electrical resistivity	* 34 - 89	µohm.cm

Optical properties

Transparency	Opaque
--------------	--------

Processability

Castability	2 - 3
Machinability	3 - 4
Weldability	2 - 3
Solder/brazability	1 - 2

Eco properties

Embodied energy, primary production	* 3.78e4 - 4.17e4	kcal/lb
CO2 footprint, primary production	* 20.8 - 23	lb/lb
Recycle	✓	

Supporting information

Design guidelines

Metal foams can be machined, and some can be cast to shape but at present this is a specialized process. They are best joined with adhesives, which give a strong bond. Some foams have a natural surface skin with an attractive texture, but this is lost if the foam is cut. Their most striking characteristics are their low densities, good stiffness and ability to absorb energy when crushed.

Technical notes

Metal foams are made by casting methods that entrap gas in the semi-liquid metal, or by replication techniques using a polymer foam as a precursor. Once cast they are as chemically stable as the metal from which they were made, have the same melting point and specific heat, but much lower density.

Typical uses

Metal foams have promise as stiffeners to inhibit buckling in light shell structures, as energy absorbing units, both internal and external, in motor vehicles and trains, and as cores for light, stiff sandwich panels. Open cell foams have a large exposed surface area that enables their use as heat exchangers for power electronics. Industrial designers have seen potential in exploiting the reflectivity and light-filtering properties of open cell foams, and the interesting surface textures of those with closed cells.

Tradenames

Duocell, Alporas

Links

Reference

ProcessUniverse

Producers