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Engineered cellular materials widely used in structural applications have similarity to those in nature. Wood, cork, and a human cancellous bone are examples of well-known natural cellular materials that resemble foams and honeycombs used for structural engineering applications. In structural applications, one role of a honeycomb core is to maintain separation between face sheets, often for specific point loads or a range of stress states from bending to compression or even expansion. This is best done with a minimal increase in weight. Therefore, lower densities are desired to maximize the advantage of a sandwich composite.

Achievable strengths in honeycombs are determined by the base material's properties, geometry, and bonding between cells. Amorphous metals have interestingly high mechanical performance properties. However, their high elastic limit and shear band deformation mechanism have excluded traditional honeycomb processing methods for these materials. Here we demonstrate Amorphous Metal Honeycombs (AMH) using a new processing method. Out-of-plane compression tests show a higher compressive strength compared to other materials. These results validate an analytical model proposed for a teardrop celled honeycomb.

Structural hierarchies in cellular materials govern their behavior and differ in properties on more than one level. Honeycombs and foams, typically used as cores in sandwich structures, can have tailored porosities and exhibit structural hierarchy. With modern processing methods, a range of mechanical properties are now achievable using polymers, metals, ceramics, glasses, and composites in cellular form. Driven by scientific challenges and industry demand, high specific strength and cost-effective materials provide new platforms opening design constraints. In one example, every kilogram reduced from the airframe in a commercial aircraft reduced the operating cost by 9% over its lifetime. In many similar cases, higher specific strength, corrosion resistant materials immediately add value for existing designs opening new design frontiers.

Amorphous metals, also known as Metallic Glasses (MG) are a relatively new class of materials with remarkable elastic properties compared to conventional metals. Most MGs require solidification at high cooling rates (10^5-10^6 K/s), limiting their size in at least one dimension. Recently, lower critical cooling rates have been demonstrated in Bulk Metallic Glasses (BMGs). Forming amorphous metal cellular structures is advantageous for several reasons. The high yield strengths (> 4 GPa) and Young's Modulus (>190 GPa) of amorphous alloys, along with their improved plastic deformation when below a critical thickness, motivates engineering such cellular solids. Furthermore, honeycombs are 16x stronger in the out-of-plane direction than foams for the same density and base material.

A special honeycomb cell shape was developed to overcome limitations due to the high elastic limit of amorphous metal precursors. This shape permitted a range of cell sizes. Densities from 0.3 Mg/m^3 to 0.6 Mg/m^3 of Amorphous Metal Honeycombs (AMH) have now been demonstrated. Results from axial compression testing show an unprecedented compressive strength of 90 MPa. Data for the compression strength of hexagonal aluminum honeycombs follows a plastic yielding model and not an elastic buckling model up to a maximum of 60 MPa. Until now, this was the highest specific strength honeycomb. Here we have shown new honeycombs made using a scalable manufacturing method that exceeds this limit. Methods to continue to improve the specific strength are under investigation.