

Material with the highest elastic energy storage





Overview

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An international research team coordinated at KIT (Karlsruhe Institute of Technology) has developed mechanical metamaterials with a high elastic energy density. Highly twisted rods that deform helically provide these metamaterials with a high stiffness and enable them to absorb and release large amounts of elastic energy.

Metallic materials are the most well-known carriers of elastic energy due to their high strength and excellent workability, commonly utilized in forms such as springs and clockworks. However, the generally low energy storage density of current metallic materials hinders their application towards energy storage.

Stronger batteries, longer-lasting electric vehicles, and more energy-efficient machines could soon become a reality thanks to a breakthrough in energy storage. Several technologies rely on storing massive amounts of mechanical energy to work. Some store it using buffers, flexible structures, or energy storage devices.

Elastic elements are among the earliest utilized energy storage techniques in history. Strings in bows and elastic materials in catapults were used to control energy storage and release in ancient war times. The range and momentum of the projectile depended on the mechanical properties of the elastic elements. What are mechanical metamaterials with a high elastic energy density?

An international research team coordinated at KIT (Karlsruhe Institute of Technology) has developed mechanical metamaterials with a high elastic energy density. Highly twisted rods that deform helically provide these metamaterials with a high stiffness and enable them to absorb and release large amounts of elastic energy.



What is high enthalpy elastic metamaterial?

Nature 639, 639–645 (2025) Cite this article Mechanical metamaterials with high recoverable elastic energy density, which we refer to as high-enthalpy elastic metamaterials, can offer many enhanced properties, including efficient mechanical energy storage ^{1, 2}, load-bearing capability, impact resistance and motion agility.

What are elastic elements used for?

Elastic elements are among the earliest utilized energy storage techniques in history. Strings in bows and elastic materials in catapults were used to control energy storage and release in ancient war times. The range and momentum of the projectile depended on the mechanical properties of the elastic material launching them.

Are metamaterials good for energy storage?

Metamaterials ^{18, 19, 20, 21} can offer extraordinary stiffness, shape control ^{22, 23} and wave manipulation ^{24, 25} by tailoring their topologies and deformation modes ^{18, 26}, including elastic buckling ^{27, 28}. A higher-yet-wider buckling plateau on load-deformation curves is desirable for greater energy storage (Fig. 1h).

What are hyperelastic materials?

Hyperelastic materials include most polymers and rubbers, which are materials normally used to absorb energy for vibration isolation applications in cars and machinery.

Where is elastic energy stored in a rod-based lattice?

Elastic energy in conventional rod-based lattices (Fig. 1c–e) is stored in rods that generally exhibit the first buckling mode when compressed (Fig. 1b and Methods).



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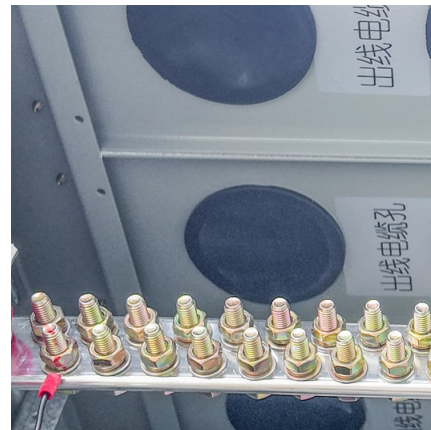


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Hyperelastic materials include most polymers and rubbers, which are materials normally used to absorb energy for vibration isolation applications in cars and machinery.

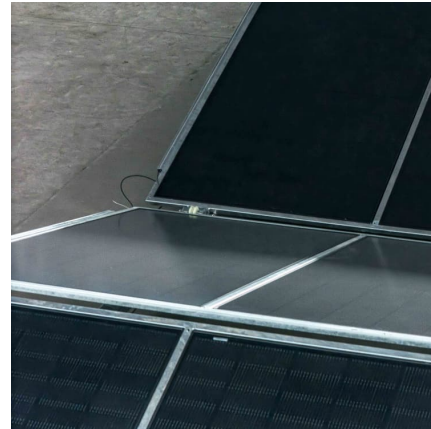


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properties. The resulting structures are ...

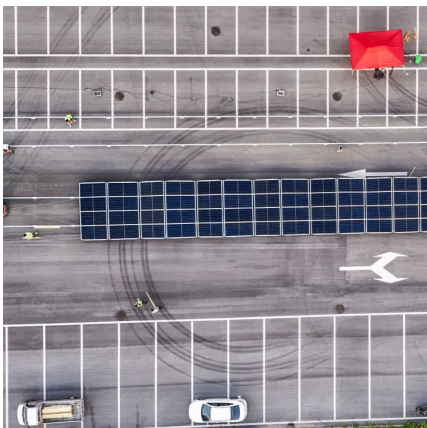


[2.080 Structural Mechanics Energy Methods in Elasticity](#)

8.2 Equivalence of the Minimum Potential Energy and Principle of Virtual Work The concept of virtual displacement u_i is the backbone of the energy methods in mechanics.

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In the biological world, materials are often heterogeneous and anisotropic, comprising components with very different elastic properties. The resulting structures are exposed to force ...



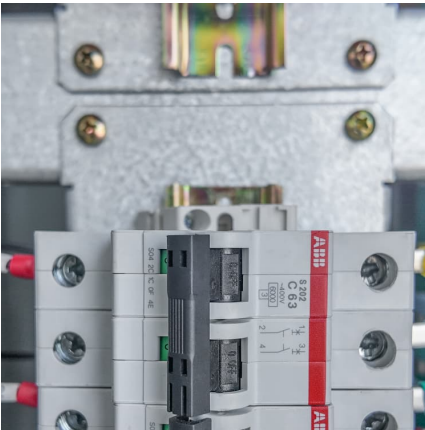
Solved Based on the "bond energy-distance" curve provided

Question: Based on the "bond energy-distance" curve provided for three materials (a,b, and c):a) Which material has the highest elastic modulus?b) Rank their melting temperatures ...

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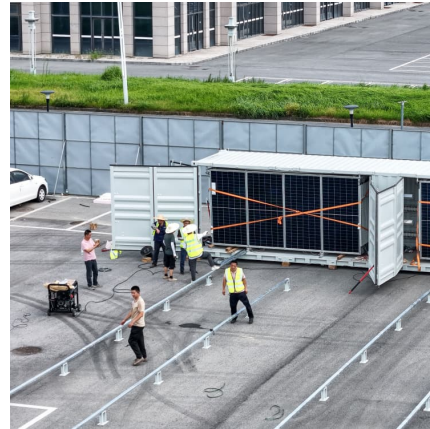


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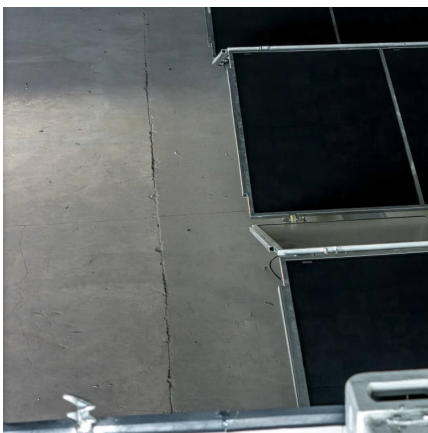
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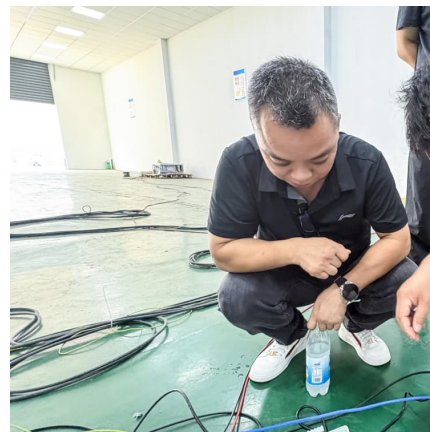
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Professor Gumbsch and his team sought to develop a material with maximum enthalpy. In their study, they discovered that a simple round rod could store large amounts of ...



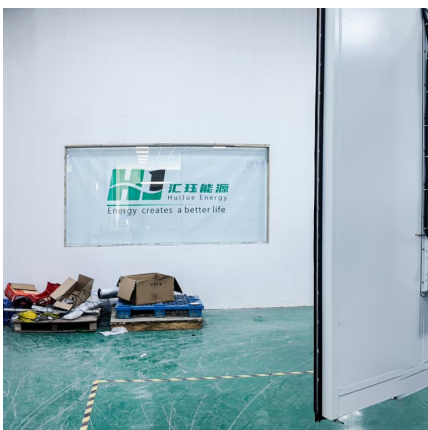
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