Application of metallic foams

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Metal foams

Light weight

Energy absorption

Thermal conduction/insulation

Large surface area
HOW can we make metallic foams?

1) Gas **Bubbling** method
2) Foam fabrication with **Preforms**
3) **Dealloying** – Chemical etching process

WHAT are the further applications of metallic foams?

1) Materials for **Hydrogen storage**
2) Military applications: **Ballistic amour**
How can we make metallic foams?
Fabricating method of metallic foams

Preforms

Gas bubbling

Dealloying
Structural applications of metallic foams

1. Light weight – environment-friendly vehicle
2. Large energy absorption rate

Metal foams can be good candidate for materials for vehicles!
Air injection method

A method to bubble $N_2$ gas into metallic melt such as Al which has low $T_m$

- **Pros**: Easy and not expensive way to fabricate closed-cell pores
- **Cons**: Too heterogeneous distribution of the pores
A method to bubble $\text{H}_2$ gas by adding blowing agents such as TiH2 which evaporates at $680^\circ\text{C}$

Since the TiH$_2$ powder can be distributed homogeneously during melting process, the pores spread much well
Applications for heat sinks

1. Large surface area to contact the cold atmosphere such as air, water etc.
2. The pore structure can hinder the heat transfer as well as give path to conduct

➤ Al or Cu foams are good for heat radiating applications
Chemical/Electro deposition

CVD technique for Inco Nickel Foam production (2004)

Metals can be deposited on polymer/ceramic/metal templates to fabricate well-ordered foam structure

- **Pros**: Easy to control the foam structure
- **Cons**: Remaining templates can degrade the mechanical properties

\[ \text{ex) } Ni(CO)_4 \rightarrow Ni + 4CO \]
Porosity can be created by infiltration of a bed of hollow spheres to create syntactic foams and infiltration of salt space-holder particles which are removed by dissolution in acidic solutions

- **Pros**: Easy to form the open-cell structure whose pores are homogeneously distributed
- **Cons**: The space holders can contaminate the materials
1. **Large surface area** can enhance not only the bio-compatibility, but also catalytic efficiency.

2. The pores should be **connected**: open-cell type.

Metal foams provide even larger surface area than bulk materials.
Thermal shielding property: Resistance to thermal flux

Nucleation and growth of nanoporous copper ligaments during electrochemical dealloying of Mg-based metallic glasses, Xuekun Luo et al. (2013)

- Dealloying is a common corrosion process during which an alloy is ‘parted’ by the selective dissolution of the most electrochemically active of its elements.
- This process results in the formation of a nano-porous sponge composed almost entirely of the more noble alloy constituents.
- Cons: It is hard to get exact target composition of metal foams
• The use of additive manufacturing for serialized production of orthopedic implants (metals) is also increasing due to the ability to efficiently create porous surface structures that facilitate bio-compatibility.

3D printing technique offers new opportunity for metal foam markets
What are the further applications of metallic foams?
• Dealloying is a common corrosion process during which an alloy is ‘parted’ by the selective dissolution of the most electrochemically active of its elements.

• This process results in the formation of a nano-porous sponge composed almost entirely of the more noble alloy constituents.

Composites fabricated from metal foam have disadvantages against dynamic stress.
Fiber-reinforced composite materials have become important engineering materials used such as marine bodies, aircraft structures and **light-weight armor for ballistic protection** in military applications.
Due to its light-weight and high impact energy absorption capabilities, composite metal foams have shown **good potential for ballistic armor**.

- Composite metal foam processed by powder metallurgy technique as a **bullet kinetic energy absorber interlayer**.
Hydrogen diffusion into alloys

Interstitial Diffusion

- Diffusion involves atoms that migrate from an interstitial position to a neighboring position that is empty.

Hydrogen is the **smallest atom** in the nature.

- Hydrogen molecules have **large tendency to diffuse** in the alloy matrix.
- Since the interstitial hydrogen atom can hinder the movement of dislocations, it can **embrittle the commercial alloys** such as steels.
The global market for hydrogen storage is expected to witness a CAGR of 7.6% during the forecast period due to the increasing focus of key players to produce alternative renewable energy from fuel cells, hydrogen and oxygen.
Hydrogen storage in metallic materials

• Since hydrogen atoms have high diffusivity, it is easily diffused into lattice at high temperature and out at low temperature.

• Hydrogen can easily be stored in metal matrix by forming hydrides such as Mg-H, Zr-H, Ti-H and so on.

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Current status of structural materials: Applications of metallic foams

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1. Hydrogen storage and transport in metallic materials
2. Challenges and solutions
3. Future directions and technologies
Metal foam is a good candidate for hydrogen storage materials by forming hydride.
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