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# Predicting Mechanical Properties of Lattice Structures


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## Overview

A superalloy, is an alloy that exhibits several key characteristics including remarkable mechanical strength and durability at high and cryogenic temperatures (e.g. Figure 1), impact strength, fatigue properties, and oxidation resistance. One of the main reasons that delays the widespread usage of superalloys in aerospace structure is their relative high densities. For instance, the density of Ni (7.8 g/cm$^3$), Ti (4.5 g/cm$^3$) are greater than conventional lightweight materials such as Al (2.70 g/cm$^3$). Manufacturing Lattice Structures (LS) made of superalloys could be an effective solution for applications where a balance between the weight and high strength at extreme temperatures is essential. Therefore, the objective of this study is to identify and quantify the optimized topology (Figure 2) for impact conditions at different temperatures.

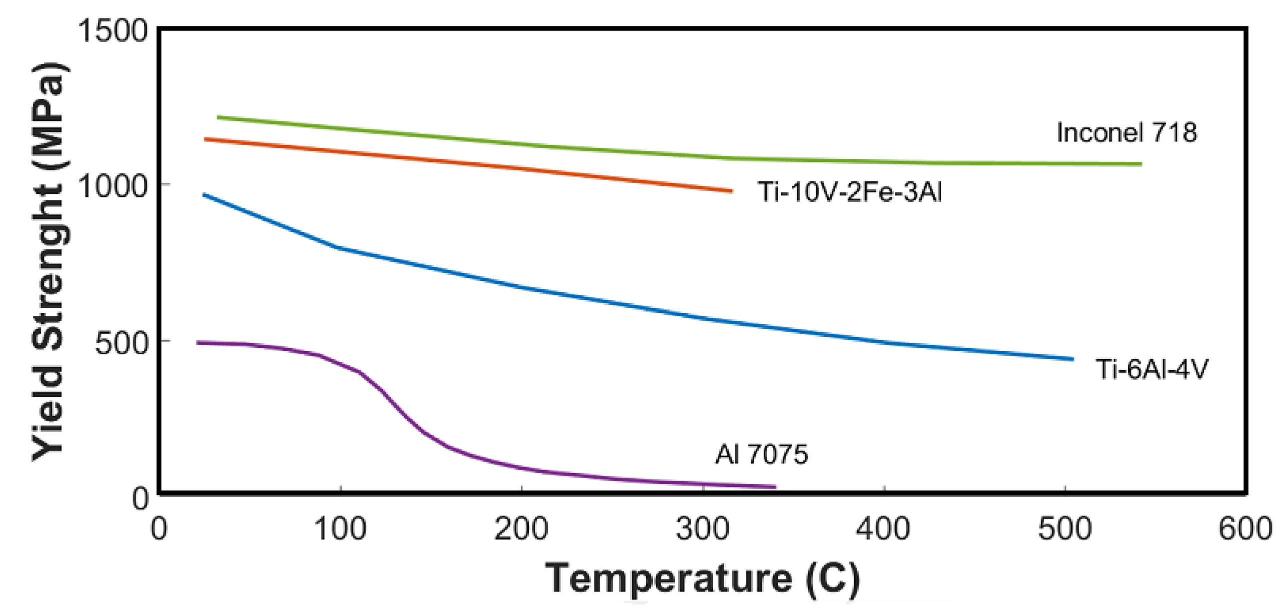
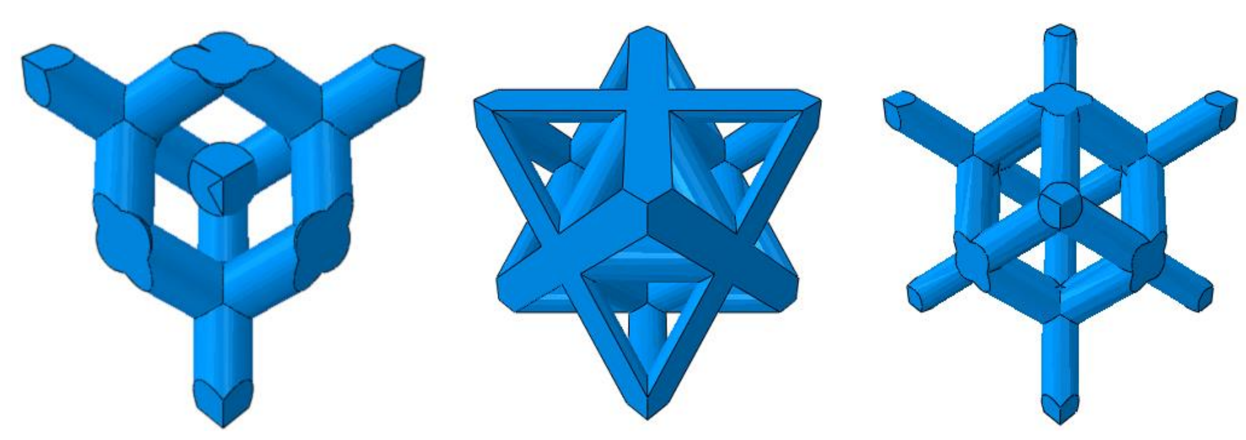



**Figure 1.** Yield strength sensitivity to temperature in Aluminum 7075, Inconel 718, Ti10V2Fe3Al, and Ti6Al4V.



Diamond Rhombic-Dodecahedron Octet-Truss

**Figure 2.** Different topologies.

## Explanation

One of the most common ways to investigate the dynamic response of materials is to investigate the energy absorption when subjected to external loading.

## Key Findings

Figures 3 and 4 compare the energy absorption of LS materials made of Ni-based and Ti-based superalloy with a solid block made of high strength Al alloy. It is seen that the LS shows considerably higher energy absorption compared to solid bulk Al 7075 when subjected to the same amount of the force.

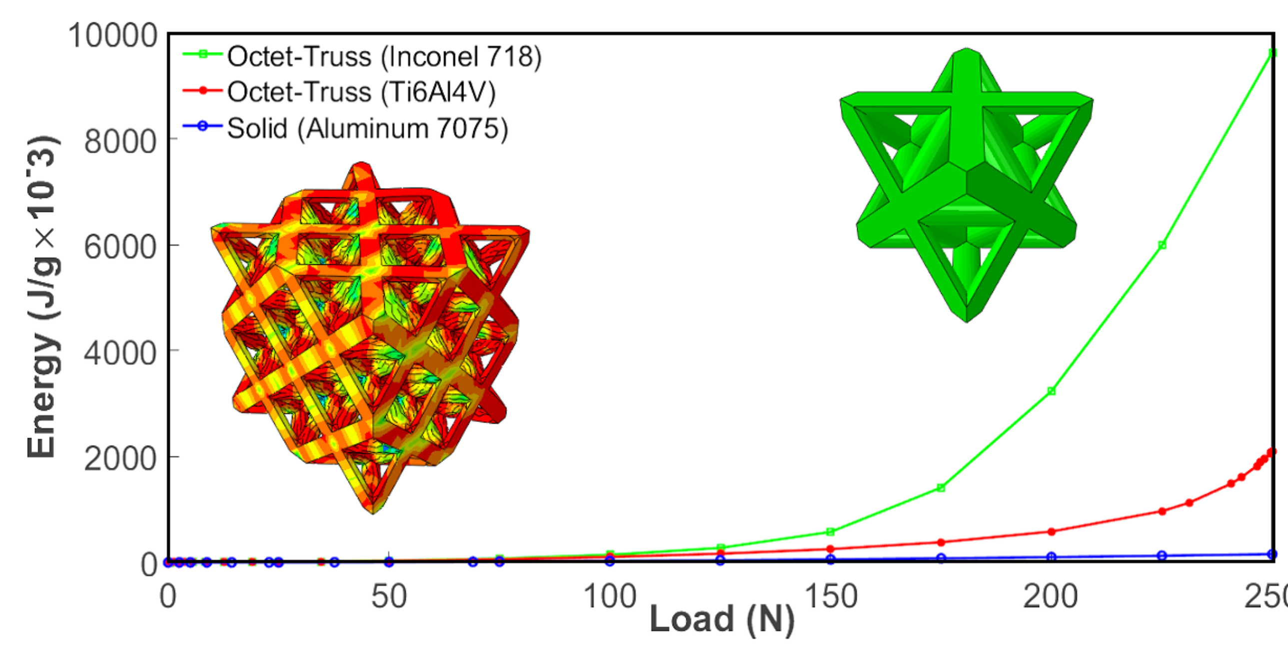



**Figure 3.** Comparison of strain energy of LS made of Inconel 718 and Ti6Al4V with solid Al 7075 using Finite Element (FEM) calculation

## Impact

The significance of implementing LS materials in critical structures is that their physical and mechanical properties can be tailored (e.g. by changing the cell topology) for a specific application and their properties are not limited by the nature of the materials that they are made of.

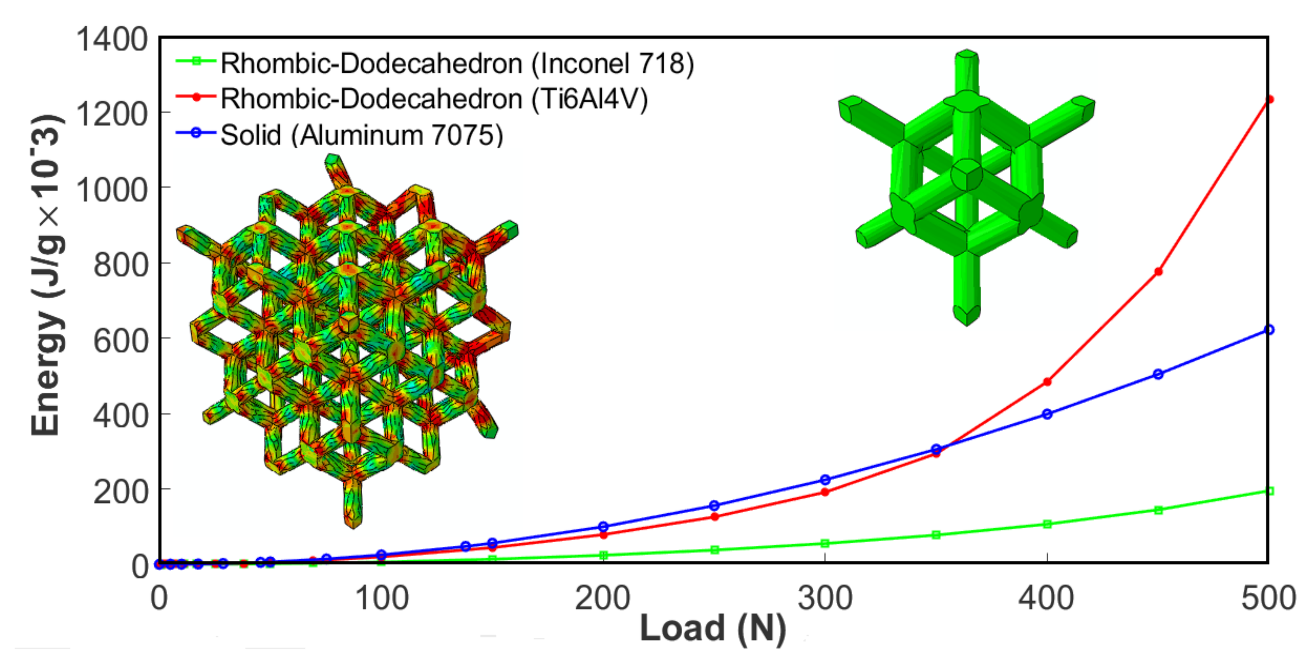



**Figure 4.** Comparison of plastic dissipation energy of LS made of Inconel 718 and Ti6Al4V with solid Al 7075 using Finite Element (FEM) calculation

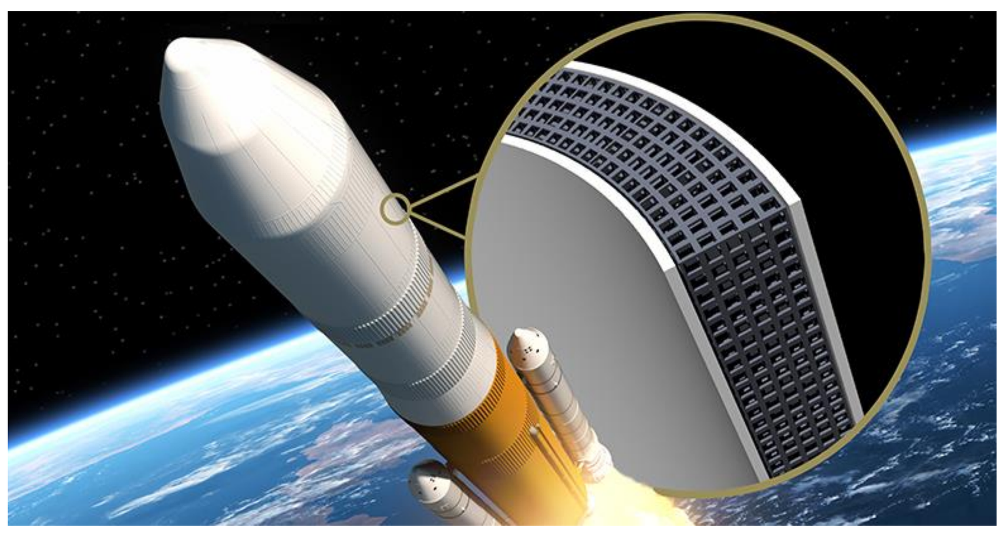


**Figure 5.** Potential application for LS materials in rocket's body and boosters. Courtesy : Jung-Chew Tse, ETH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