UNIVERSITY OF CAMBRIDGE

The materials age

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Stone age: 3.4 million BC – 2000 BC

1.9 million BC
Olduvai Gorge, Tanzania

Bronze age: 2000 BC – 1000 BC

1.9 million BC
Olduvai Gorge, Tanzania

1200 BC
Britain

Iron age: 1000 BC – 1850 AD

1.9 million BC
Olduvai Gorge, Tanzania

1200 BC
Britain

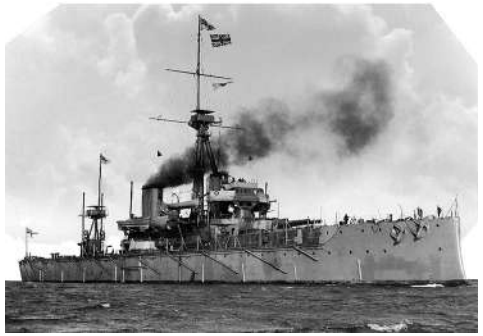
300 BC
Yorkshire

Steel age: 1850 AD – 1930 AD

1.9 million BC
Olduvai Gorge, Tanzania

1200 BC
Britain

300 BC
Yorkshire



1906
Portsmouth

Modern materials: ceramics

Modern materials: plastics

Modern materials: composites

Modern materials: rubbers

- Potential energy in elastic band

$$E = \frac{1}{2}kx^2 = \frac{1}{2}Fx = \frac{1}{2}10 \times 0.1 = 0.5\,\mathrm{J}$$

Modern materials: rubbers

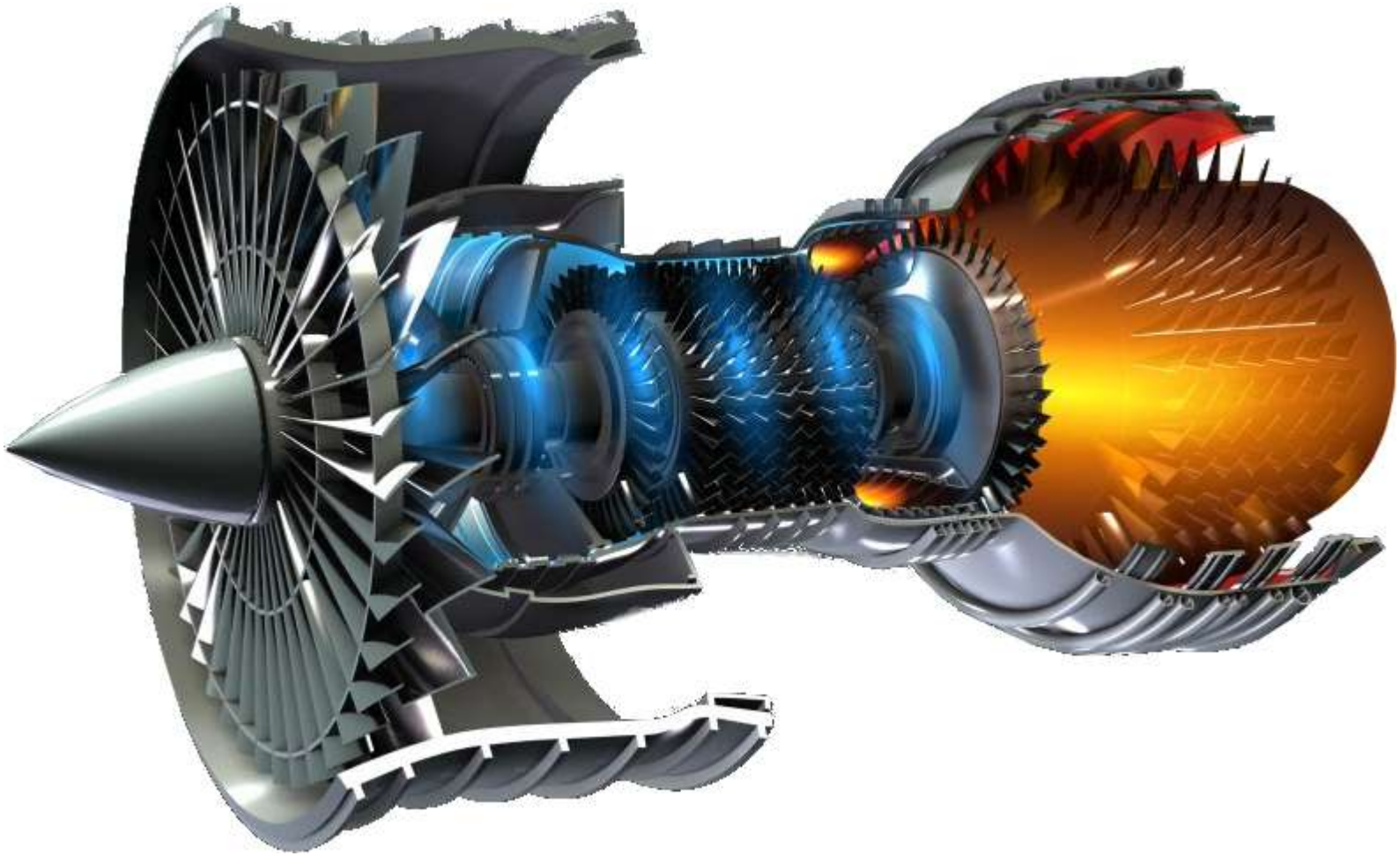
- Potential energy in elastic band $E = \frac{1}{2}kx^2 = \frac{1}{2}Fx = \frac{1}{2}10 \times 0.1 = 0.5\,\mathrm{J}$
- Kinetic energy in handgun bullet $E = \frac{1}{2}mv^2 = \frac{1}{2}0.005 \times 300^2 = 225\,\mathrm{J}$

Modern materials: rubbers

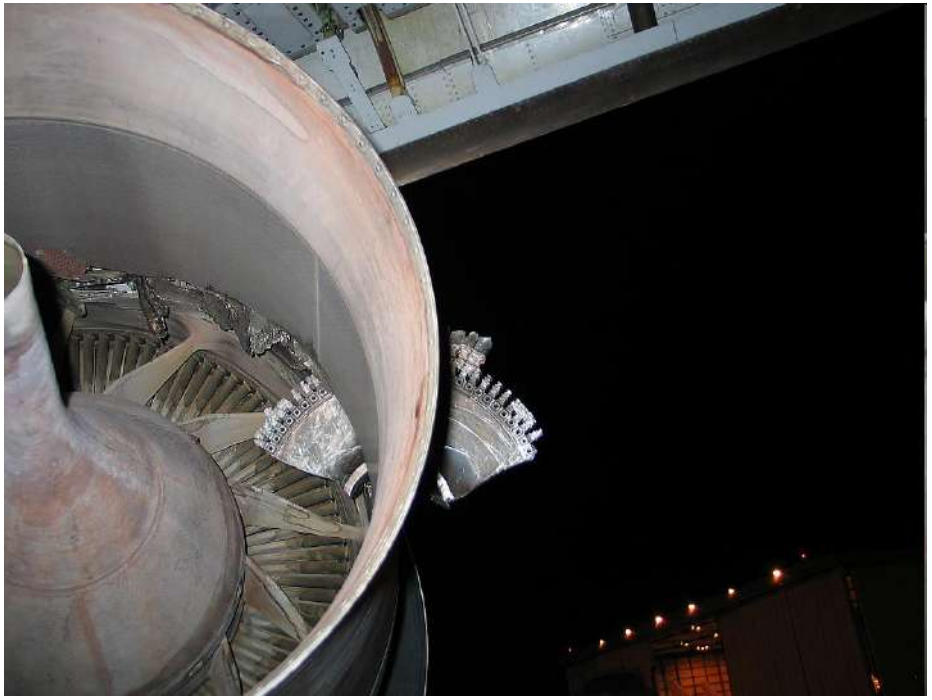
- Potential energy in elastic band $E = \frac{1}{2}kx^2 = \frac{1}{2}Fx = \frac{1}{2}10 \times 0.1 = 0.5\,\text{J}$
- Kinetic energy in handgun bullet $E = \frac{1}{2}mv^2 = \frac{1}{2}0.005 \times 300^2 = 225\,\text{J}$
- Potential energy in enormous band $E = \frac{1}{2}kx^2 = \frac{1}{2}Fx = \frac{1}{2}100 \times 5 = 250\,\text{J}$

Modern materials: alloys

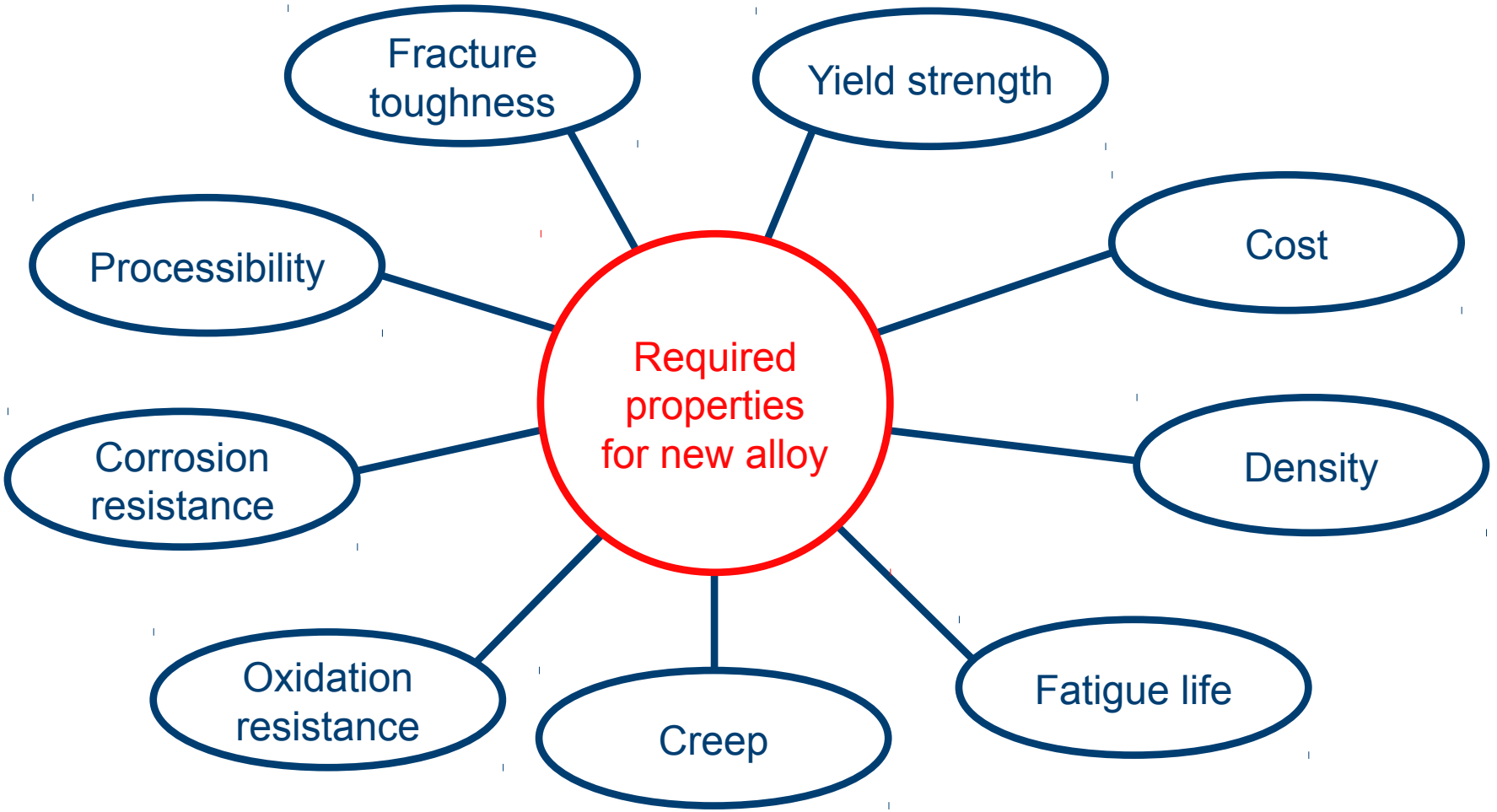
Jet engine: military jet



Jet engine: turbine discs



Designing a new alloy – what is required ?



Multidimensional design space

Cr Co Mo W Ta Nb Al

Ti Fe Mn Si C B Zr

Cu N P V Hf Mg Ni

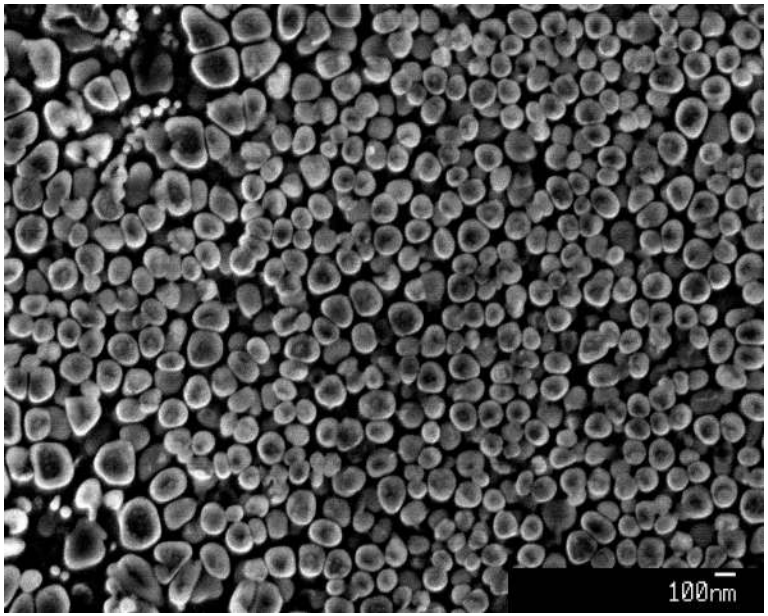
and 4 different manufacturing processes

Selection of design space

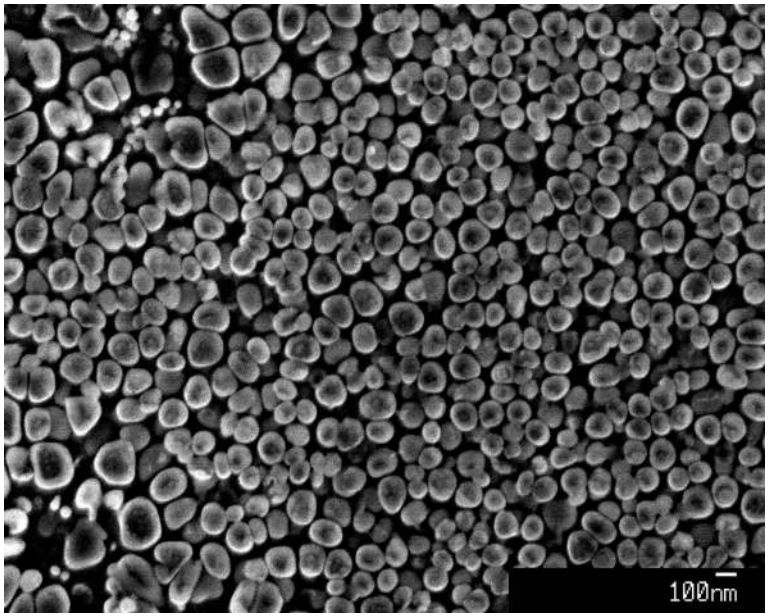
Selection of design space

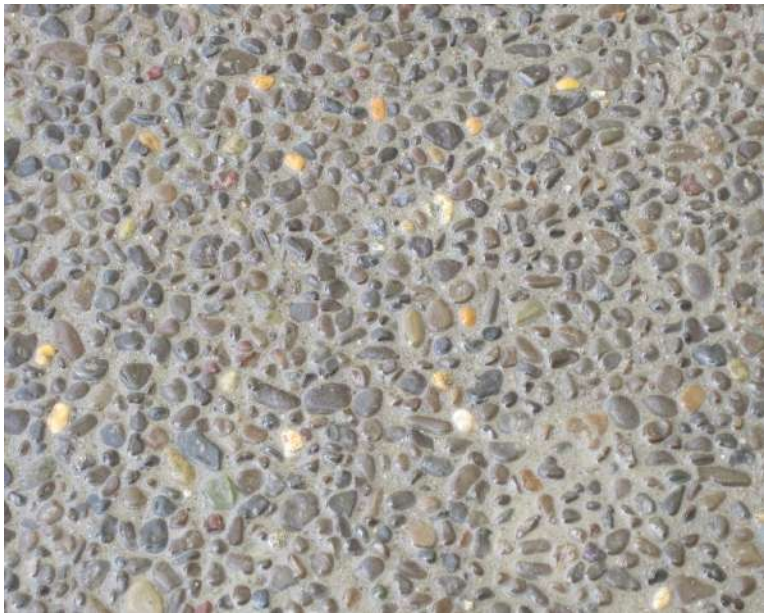
Automated sampling - parallel optimization

Predicted material

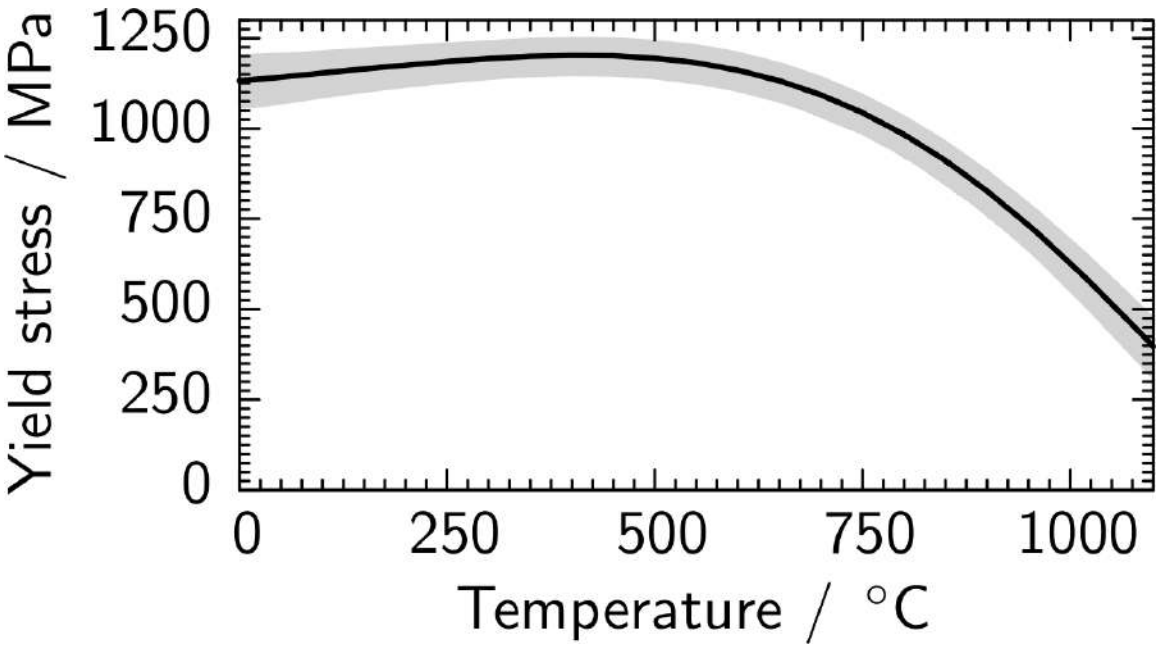


Predicted material

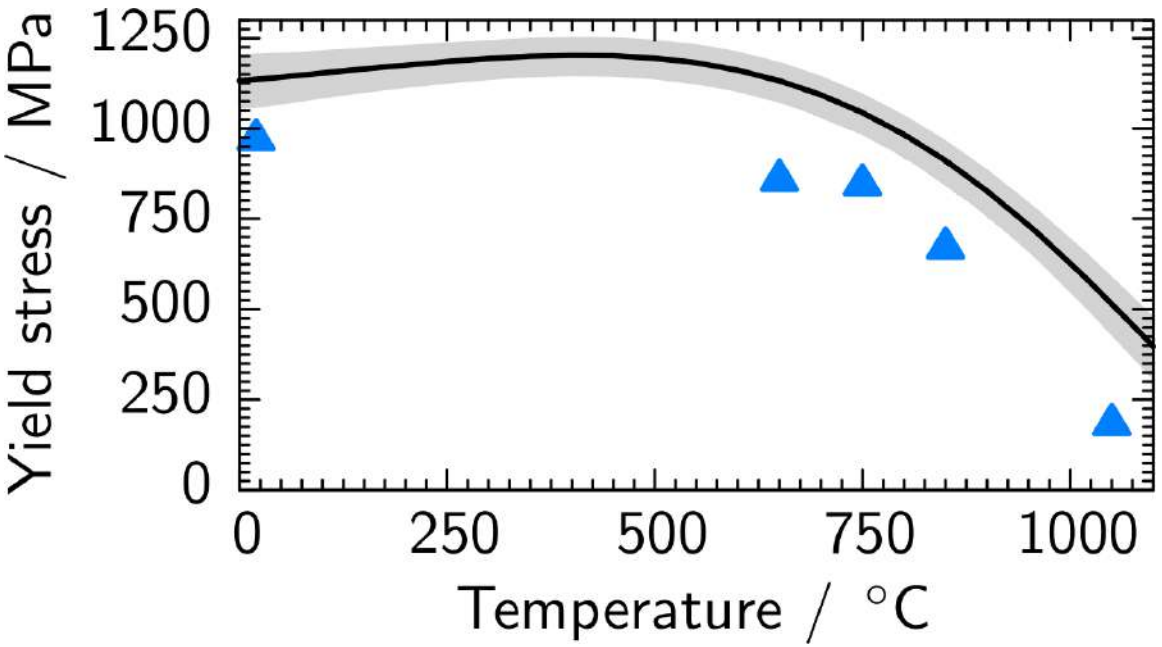




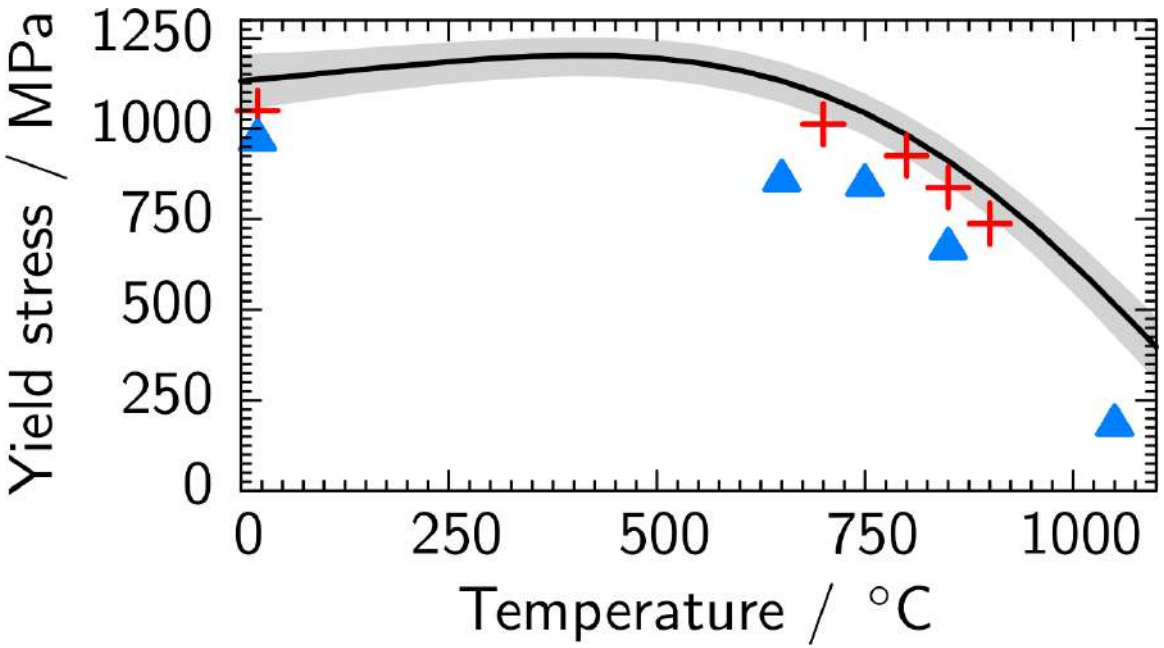
Yield stress



Yield stress



Yield stress



Conclusions: scientific

- Developed new algorithms to optimize a material's properties
- Manufactured alloys fulfill physical criteria

Conclusions: why study material sciences?

- Union of different sciences that encourages analysis with a variety of techniques – analytical, numerics, and experiments
- Close connection to real-world problems
- Strong academic funding and well-paid industrial jobs