UNIVERSITY OF CAMBRIDGE

# The materials age

**Gareth Conduit**

**TCM Group, Department of Physics**

# 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**

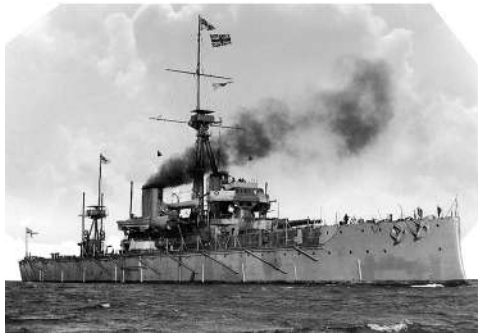
**300 BC**
**Yorkshire**

# 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

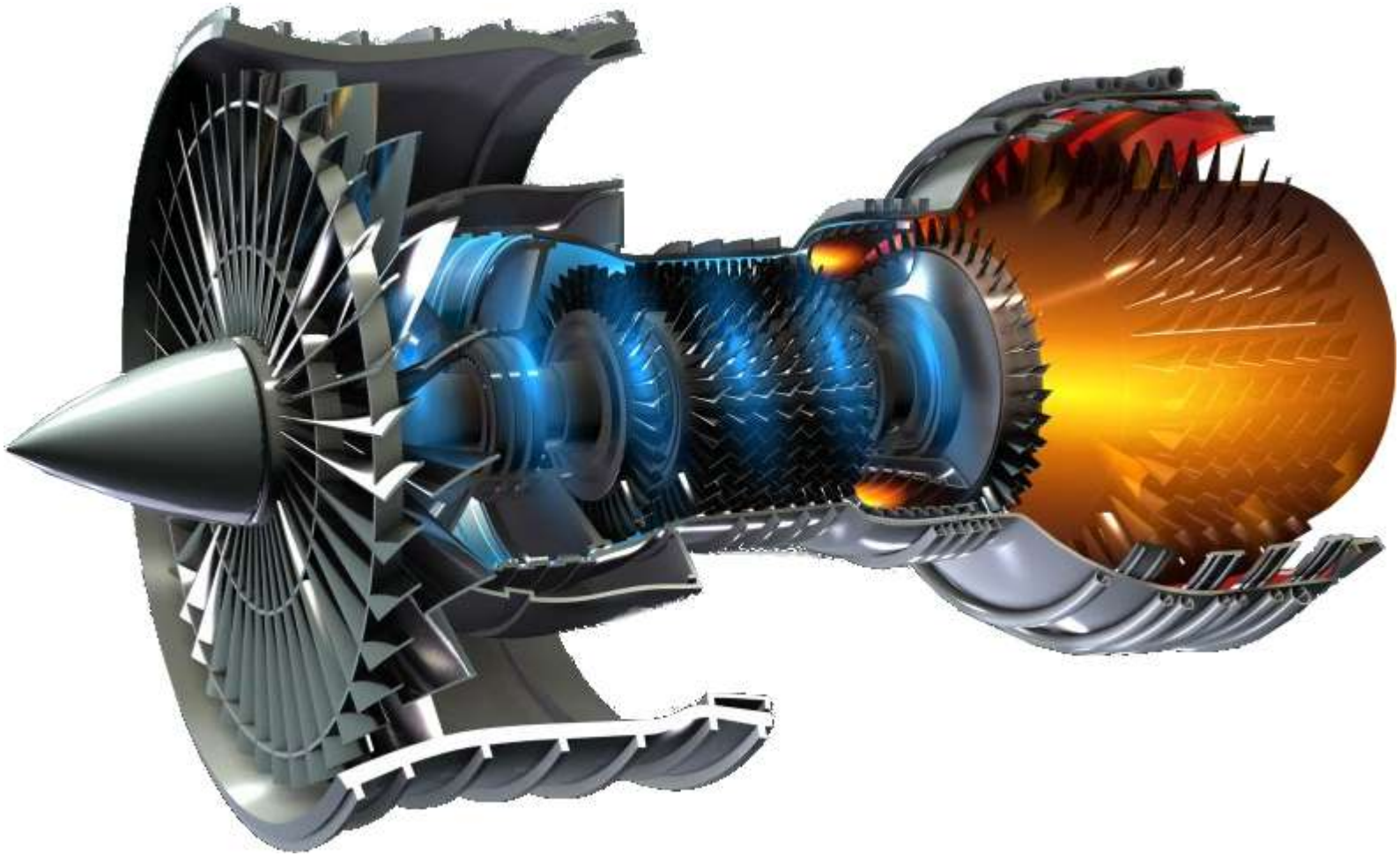
- Potential energy in elastic band $E = \frac{1}{2}kx^2 = \frac{1}{2}Fx = \frac{1}{2}10 \times 0.1 = 0.5\,\text{J}$
- Kinetic energy in handgun bullet $E = \frac{1}{2}mv^2 = \frac{1}{2}0.005 \times 300^2 = 225\,\text{J}$

# Modern materials: rubbers

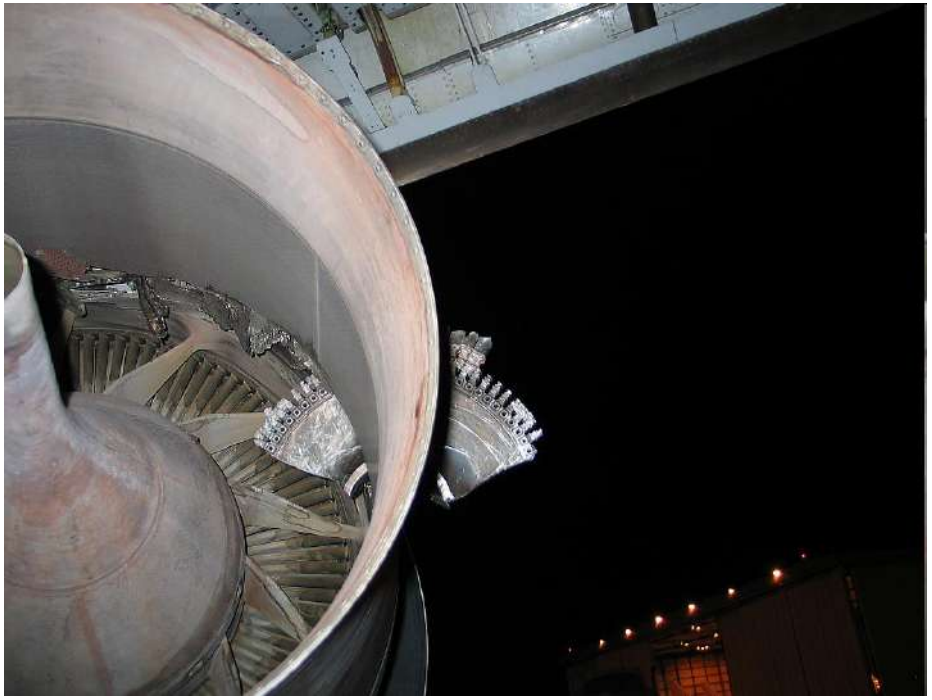
- Potential energy in elastic band $E = \frac{1}{2}kx^2 = \frac{1}{2}Fx = \frac{1}{2}10 \times 0.1 = 0.5\,\text{J}$
- Kinetic energy in handgun bullet $E = \frac{1}{2}mv^2 = \frac{1}{2}0.005 \times 300^2 = 225\,\text{J}$
- Potential energy in enormous band $E = \frac{1}{2}kx^2 = \frac{1}{2}Fx = \frac{1}{2}100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

# Modern materials: alloys

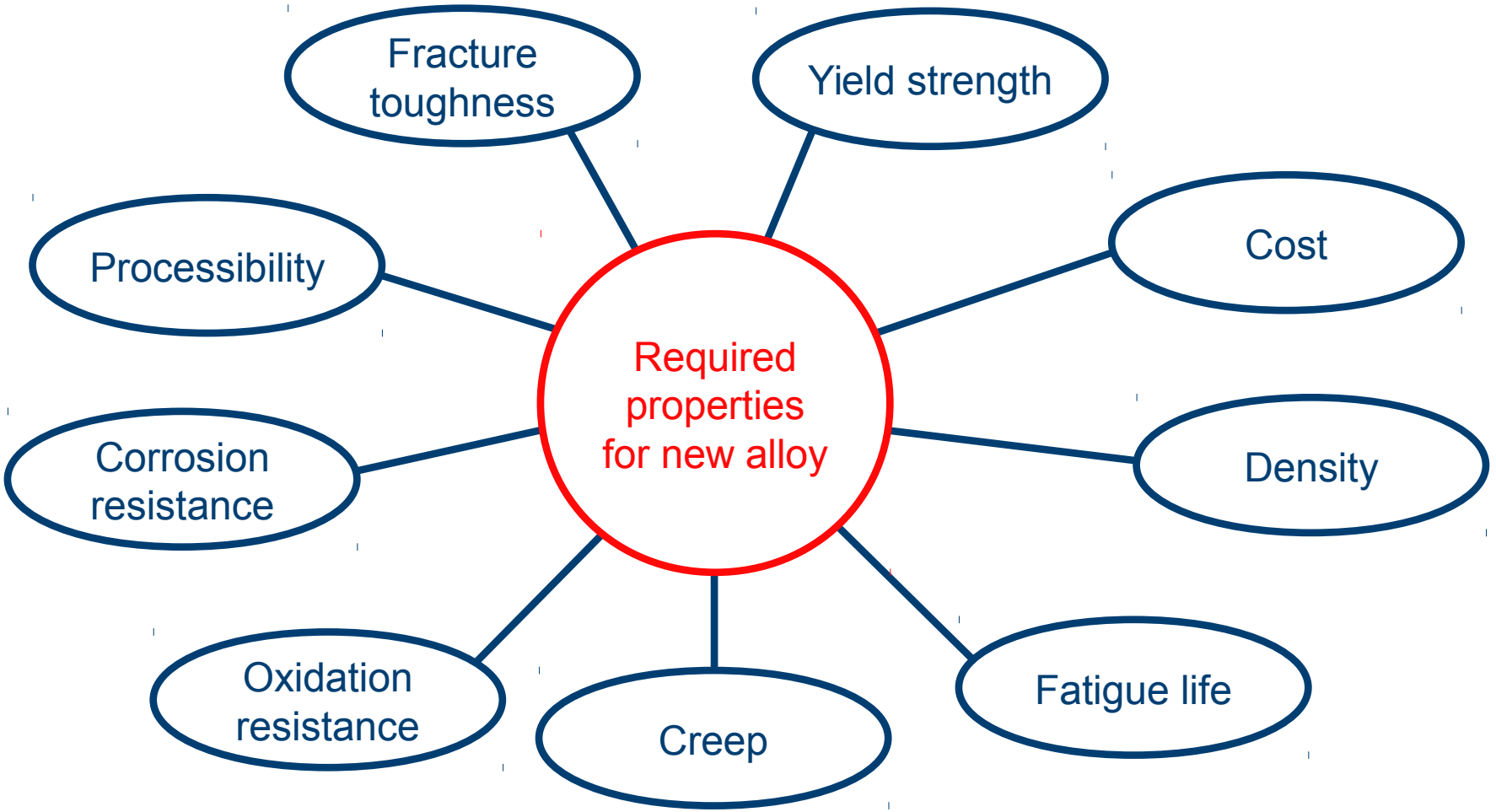
# Jet engine: military jet



# 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

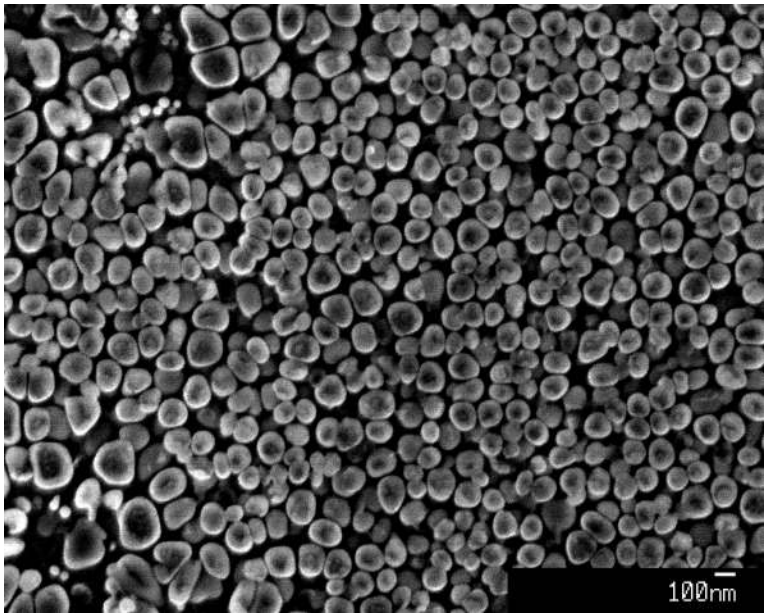
and 4 different manufacturing processes

# Selection of design space

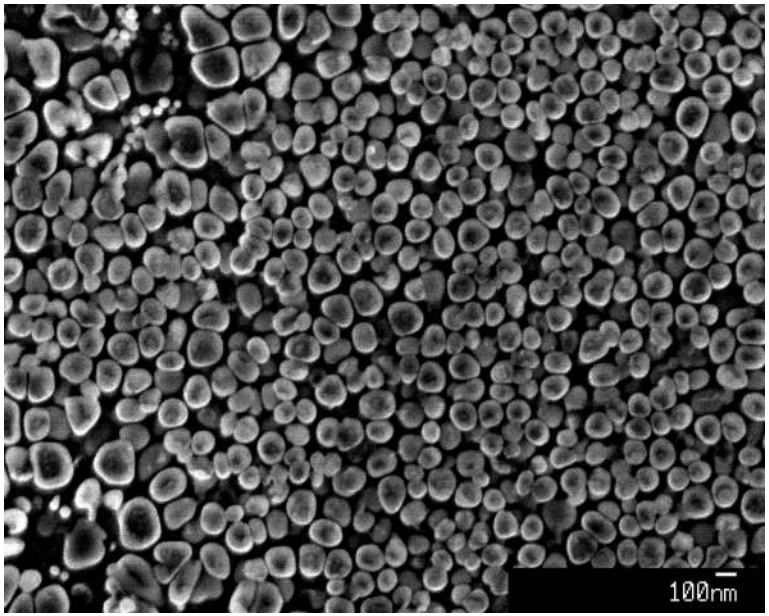
# Selection of design space

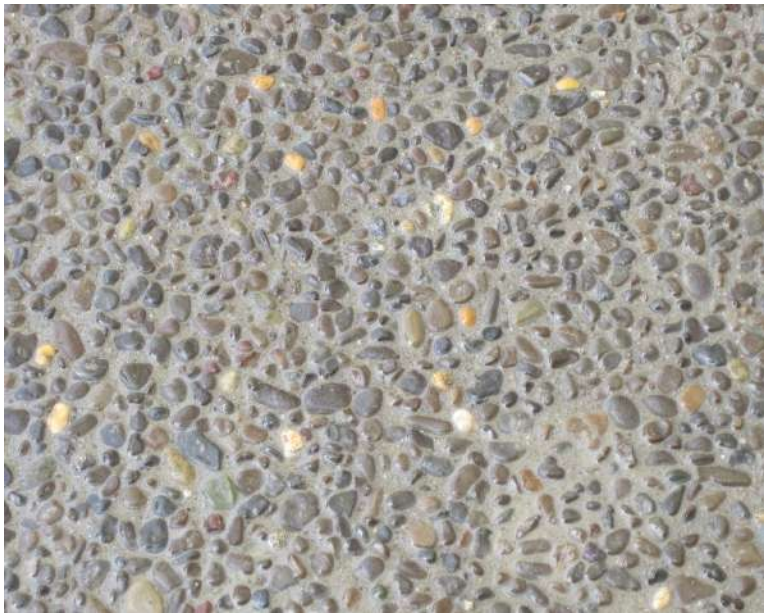
# Automated sampling - parallel optimization

# Predicted material

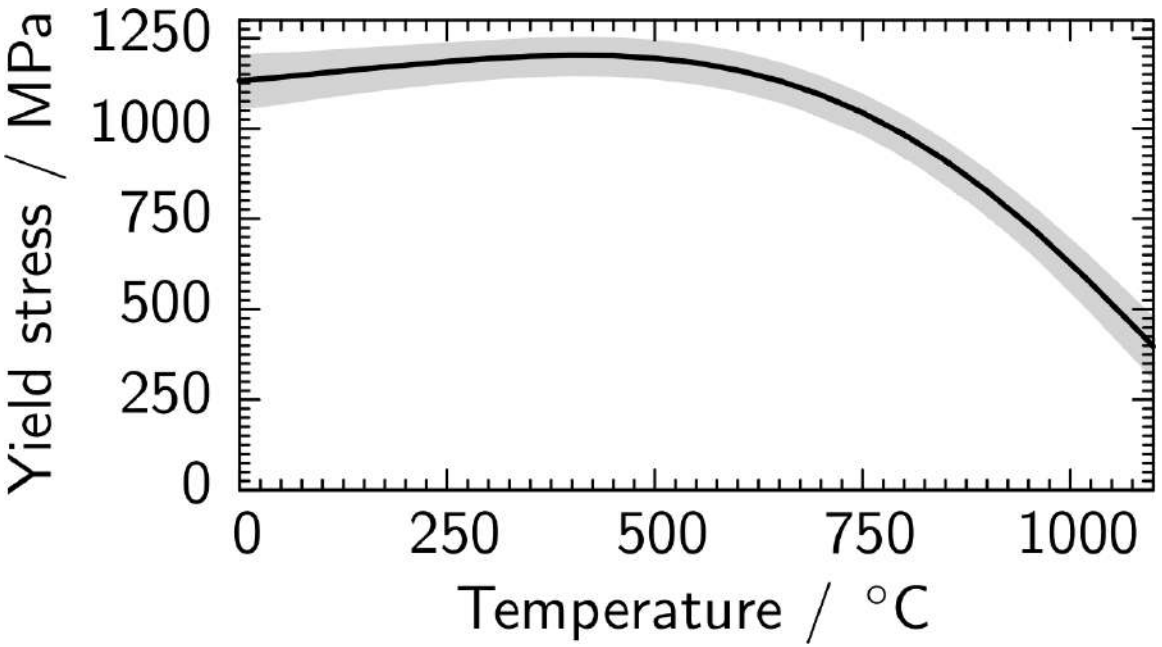


# Predicted material

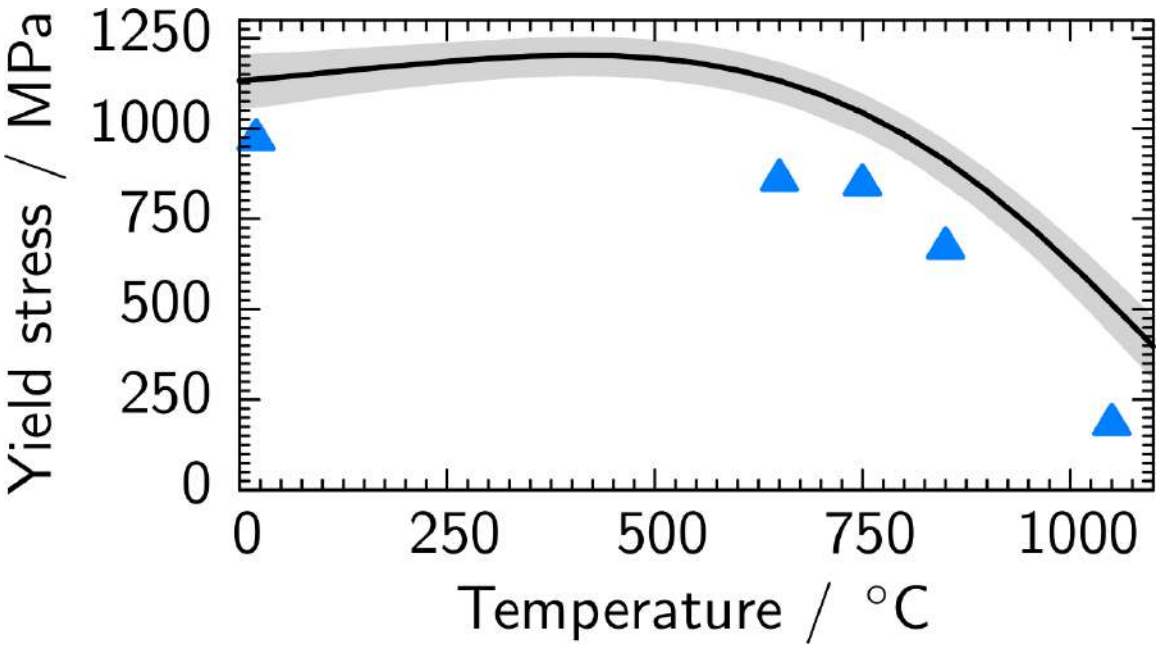


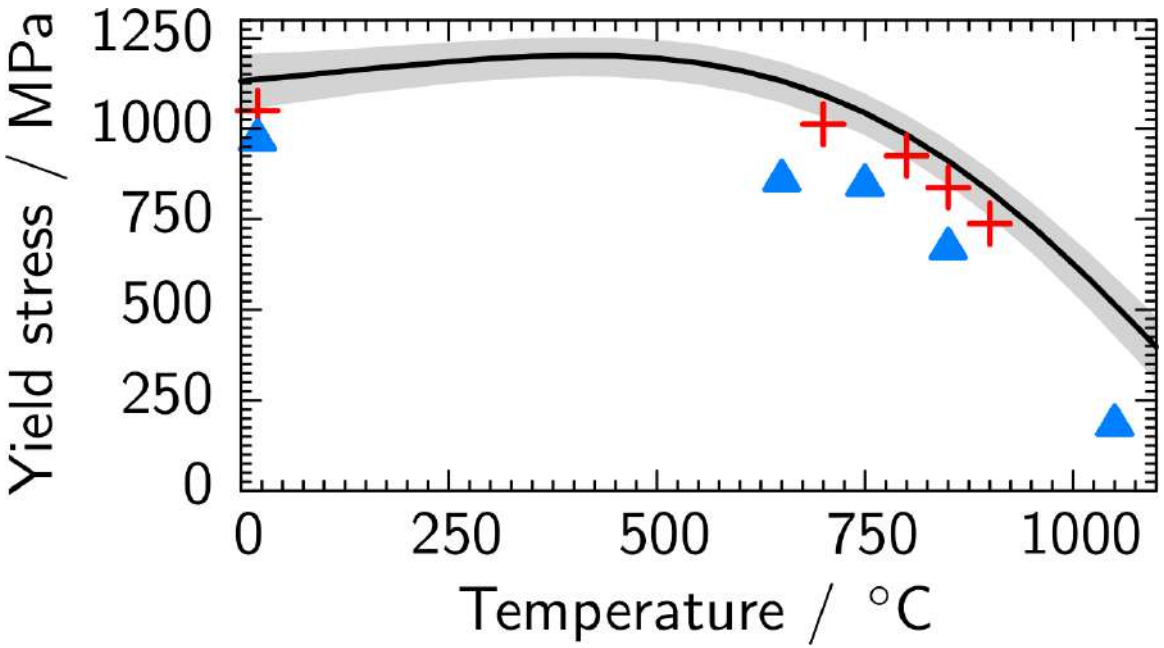
# Yield stress



# 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