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

Modern materials: rubbers

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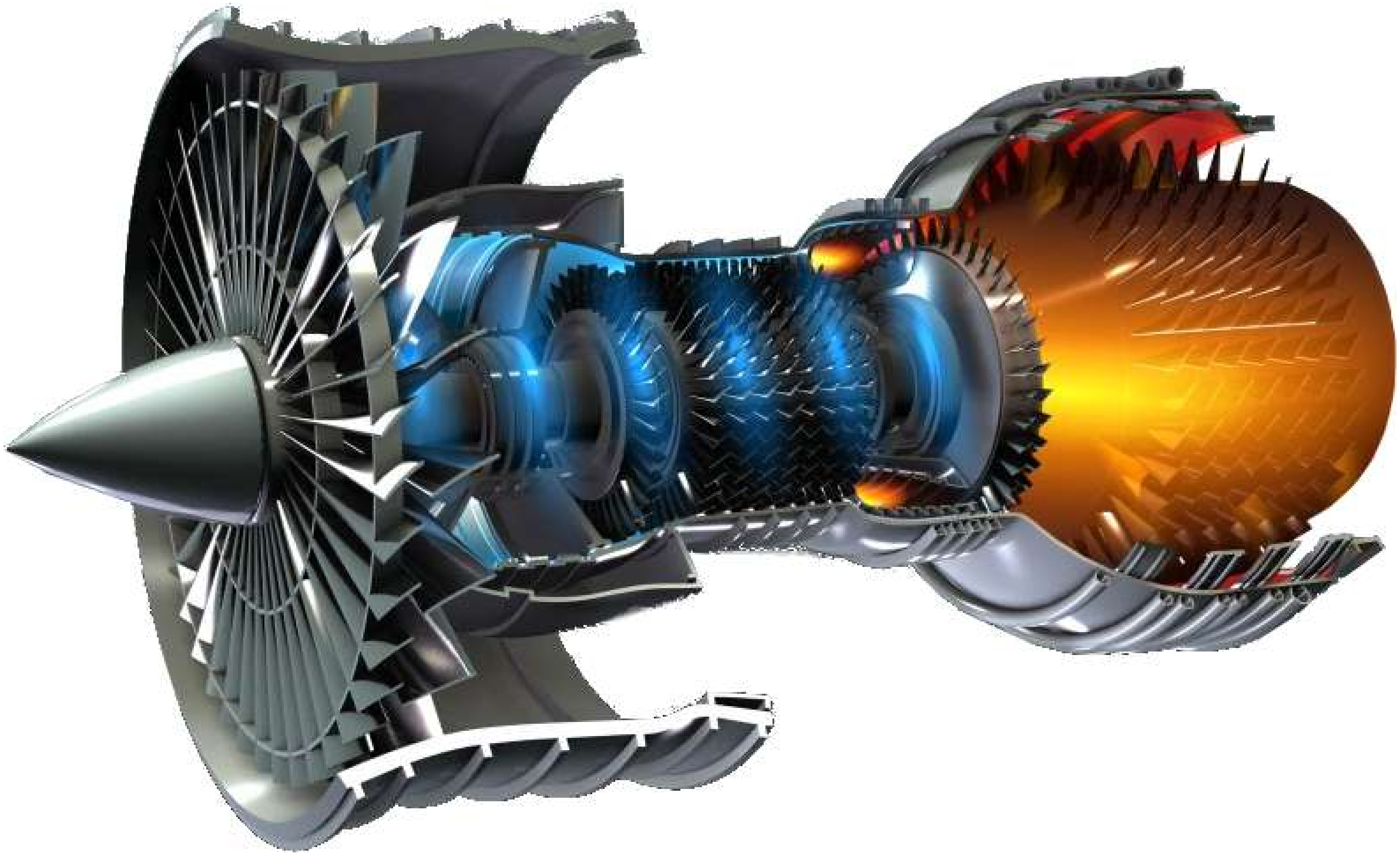
- Kinetic energy in handgun bullet $$E = \frac{1}{2}mv^2 = \frac{1}{2}0.005 \times 300^2 = 225\,\text{J}$$

Modern materials: rubbers

- Potential energy in elastic band $$E=\frac{1}{2}kx^2=\frac{1}{2}Fx=\frac{1}{2}10\times0.1=0.5\,\text{J}$$
- Kinetic energy in handgun bullet $$E=\frac{1}{2}mv^2=\frac{1}{2}0.005\times300^2=225\,\text{J}$$
- Potential energy in enormous band $$E=\frac{1}{2}kx^2=\frac{1}{2}Fx=\frac{1}{2}100\times5=250\,\text{J}$$

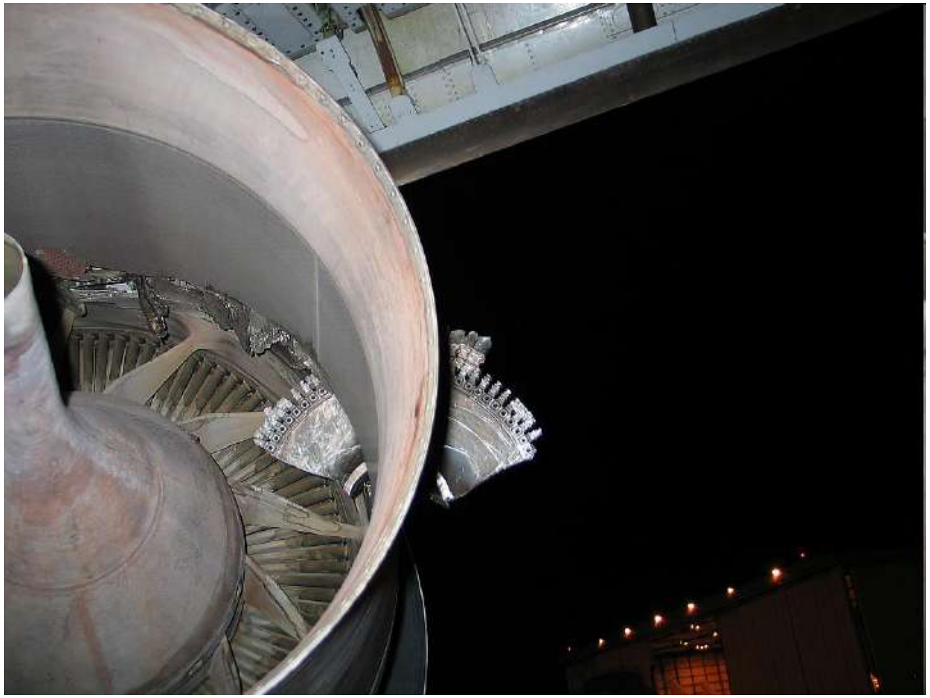
Modern materials: alloys

Jet engine: military jet

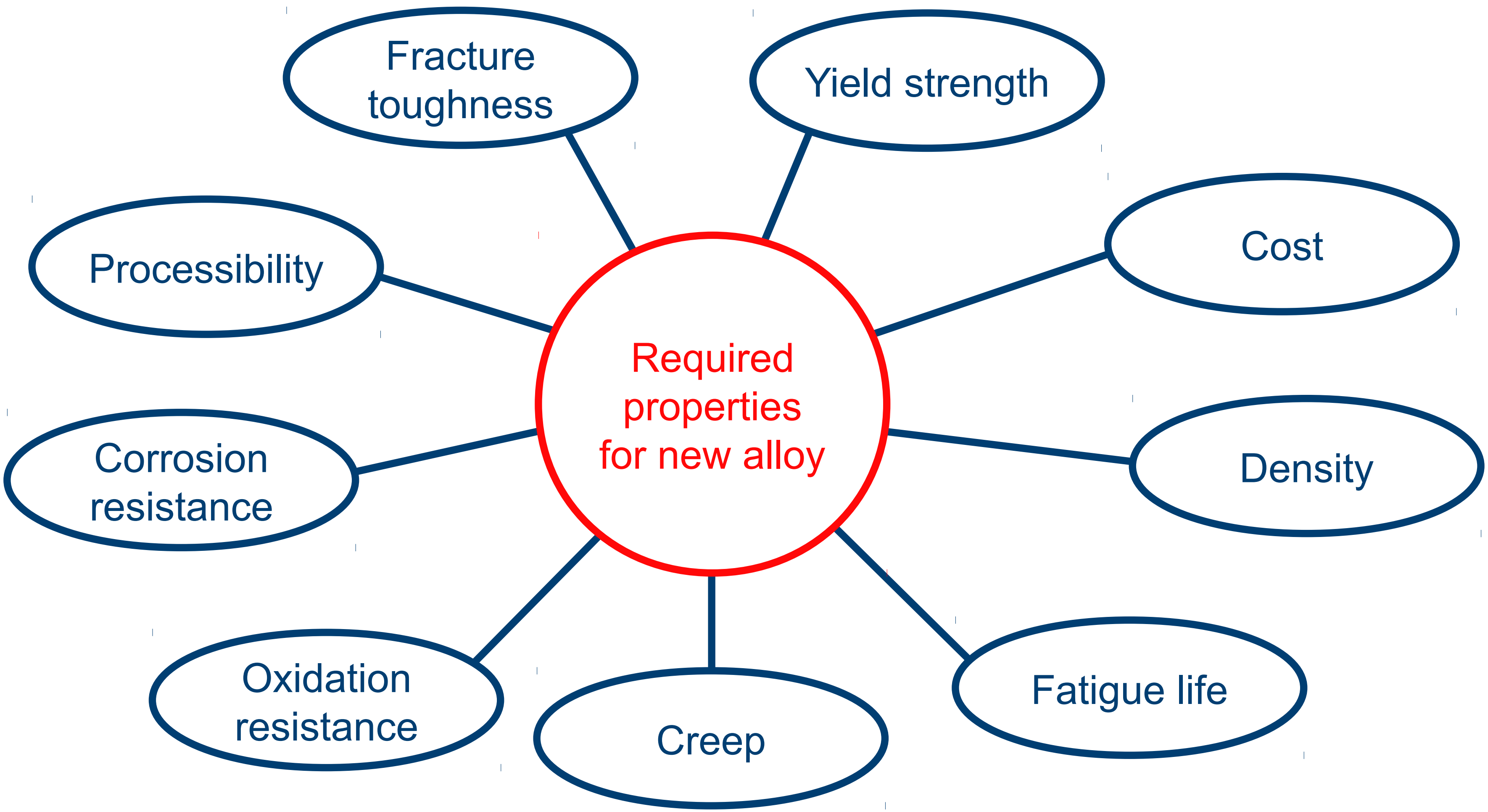


Saint Martin airport

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

Composition of proposed alloy

Cr:15.8

Co: 20.0

Mo: 0.5

W: 0.5

Ta: 4.9

Nb: 1.1

Al: 2.4

Ti: 3.0

Fe: 3.9

Mn: 0.2

Si: 0.2

C: 0.02

B: 0.06

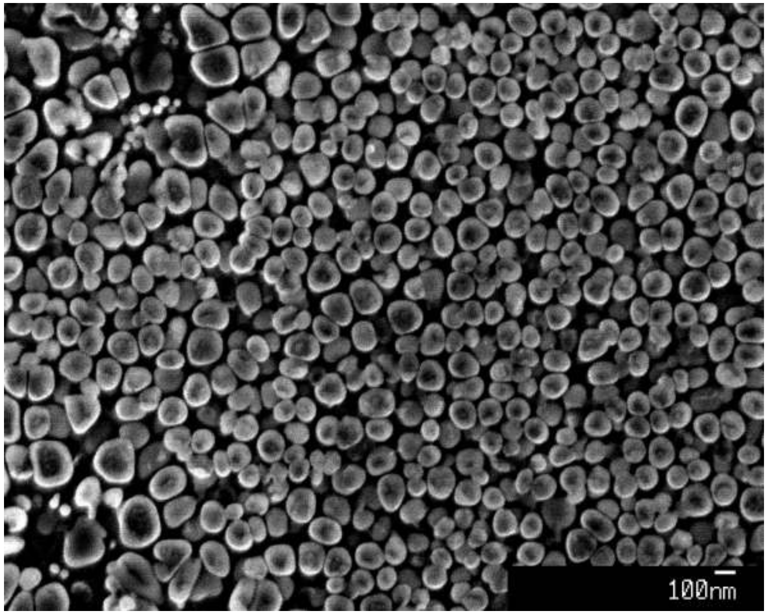
Zr: 0.18

Ni: 47.2

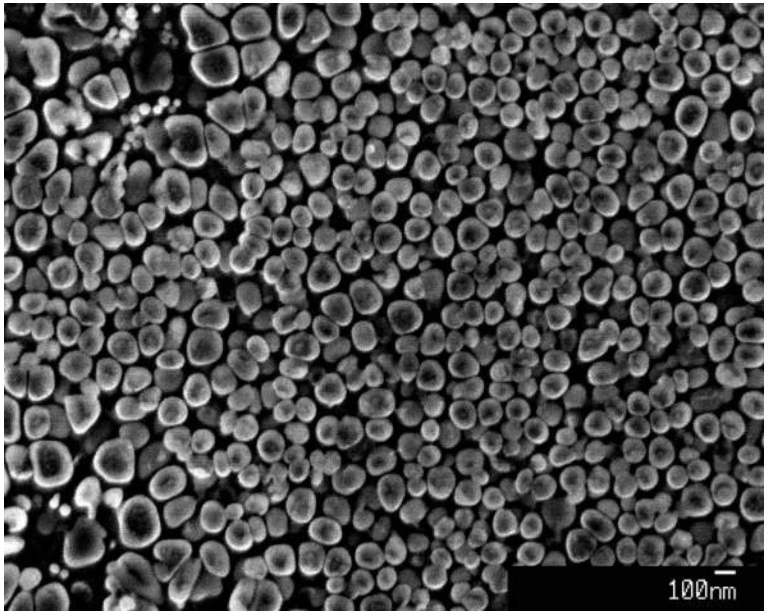
900ºC

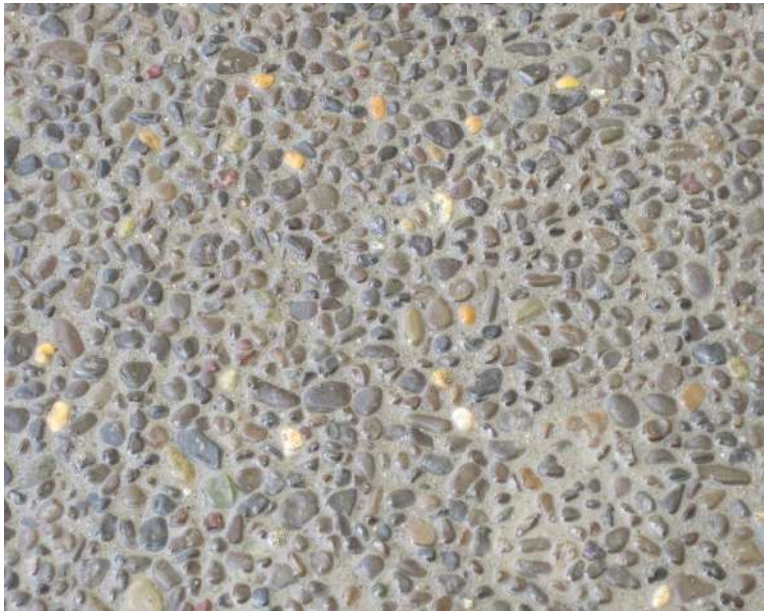
30 hours

Microstructure of proposed alloy

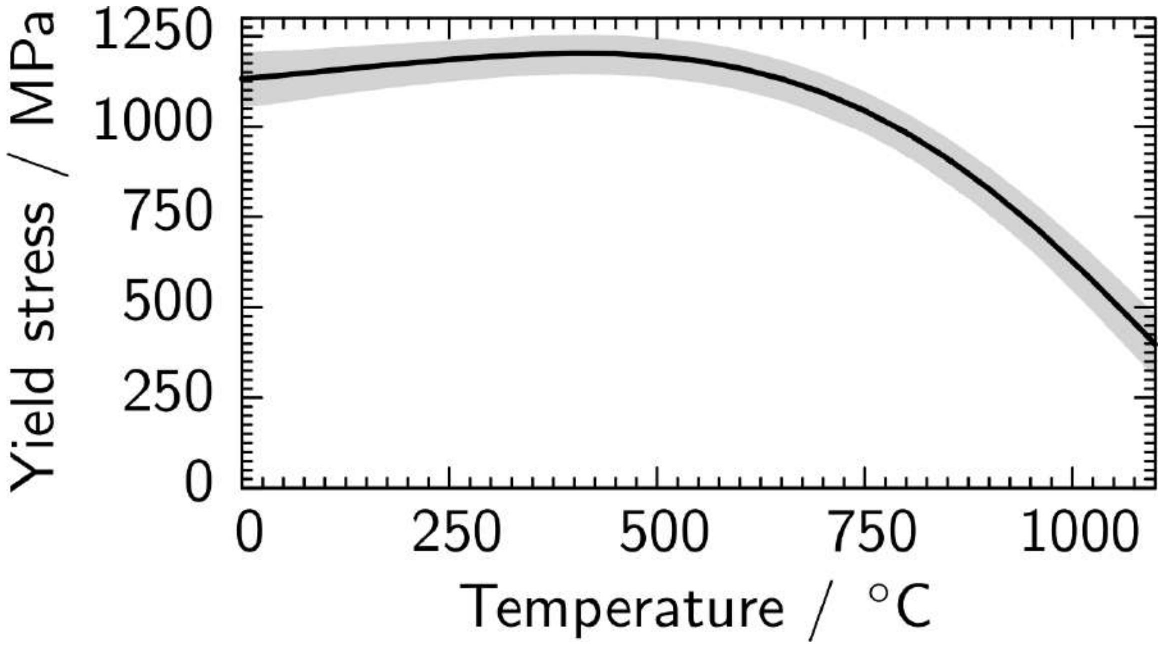


Microstructure of proposed alloy

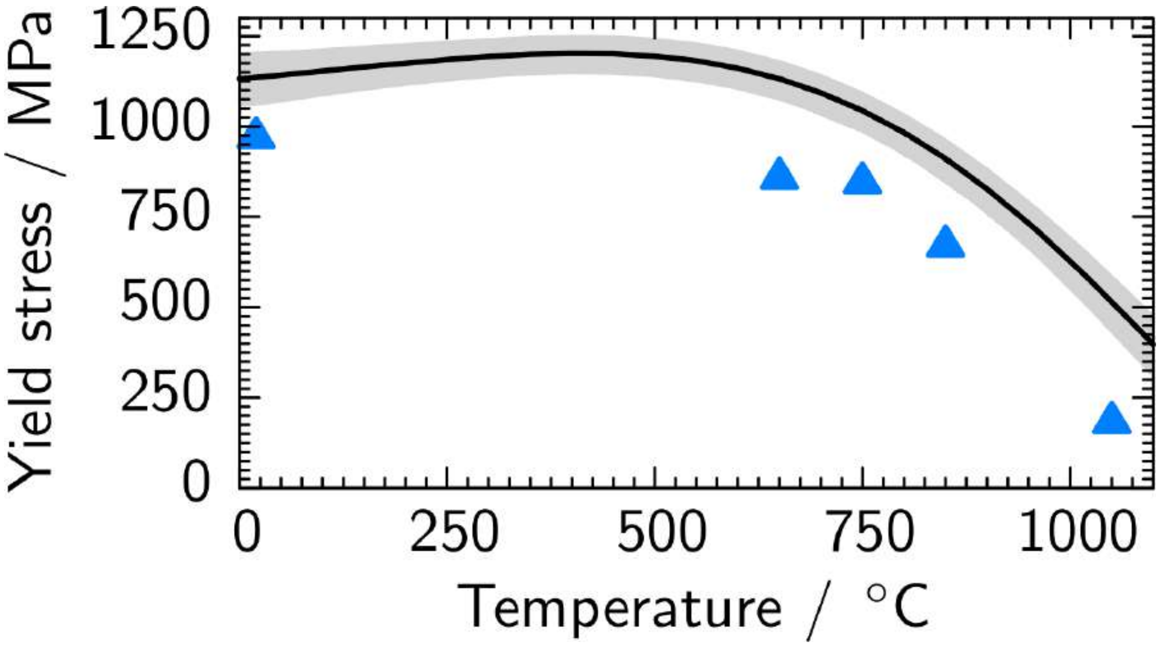




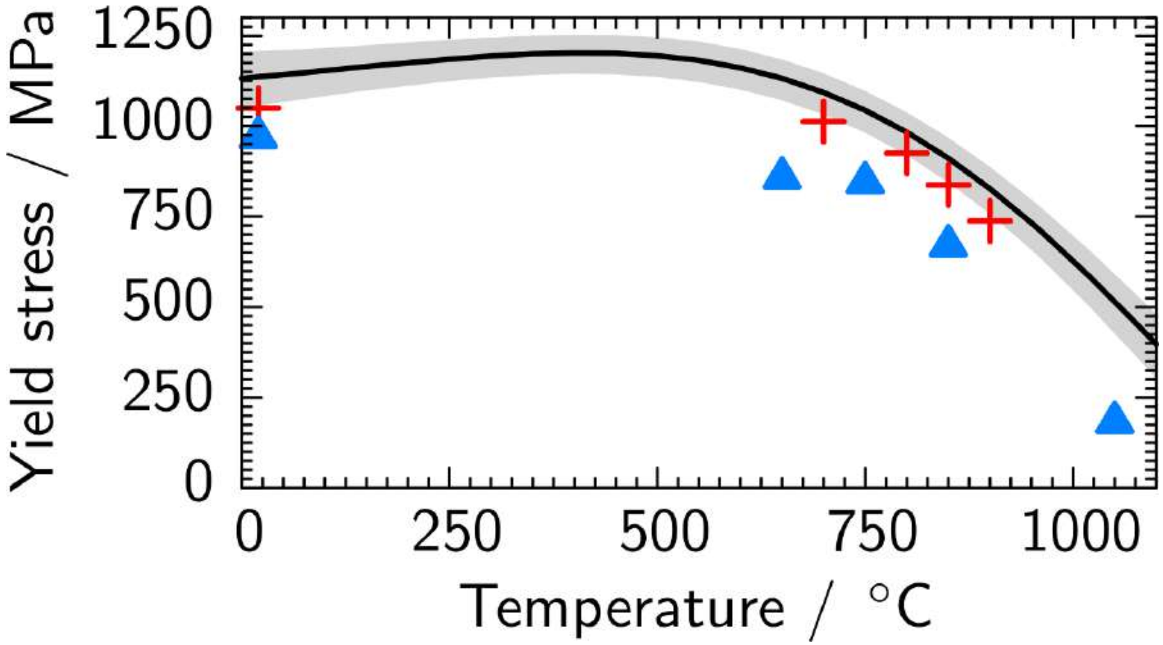
Yield stress of proposed alloy



Yield stress of proposed alloy



Yield stress of proposed alloy



Conclusions: scientific

Developed new algorithms to optimize a material's properties

Manufactured alloys fulfill physical criteria

Conclusions: why study natural 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