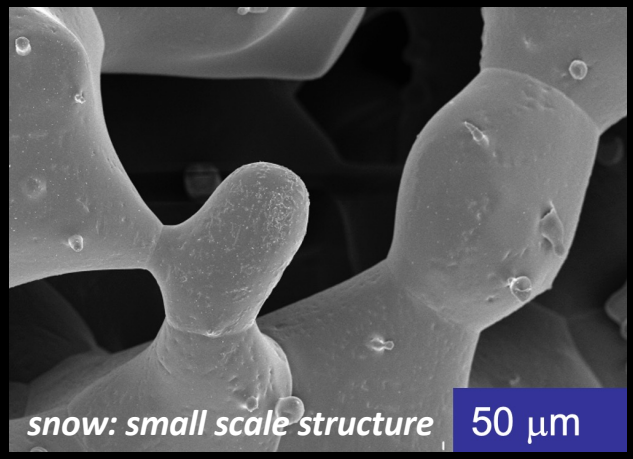
Dr Jane Blackford

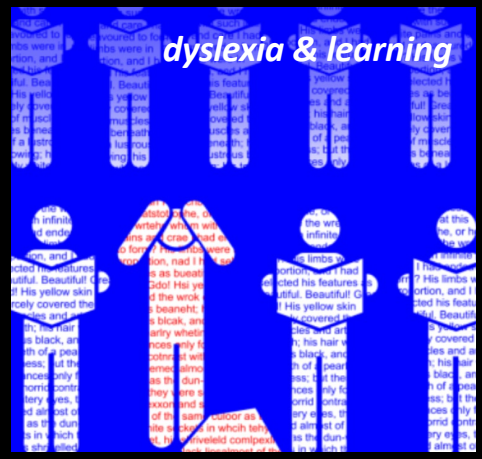
BEng Science & Engineering of Materials, and ***PhD*** Processing metallic coatings for high temperature aircraft gas turbines, *Sheffield*

Research interests interfaces between: materials – including snow and ice, microstructure, movement, learning and human connection

Characterising snow properties and microstructure. Ciste Meridh, Cairngorm, Scottish Highlands



snow: small scale structure



Materials 2 Intro session

- An introduction to the course
- Key information: Course Guide, Guide to activities for the week
- An example of materials science and engineering in practice to illustrate key principles *
- Introduction to teaching team
- Opportunity for you to ask questions

An aim of the course is that you develop a *foundational set of tools and skills for dealing with materials in engineering

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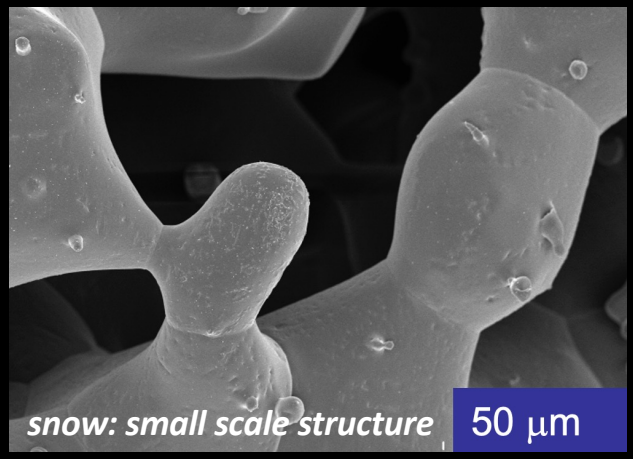

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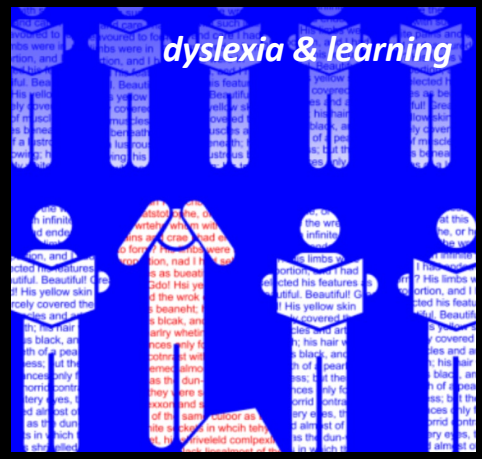
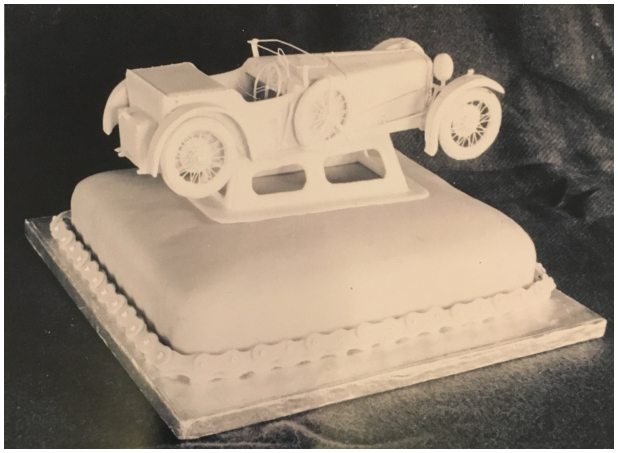
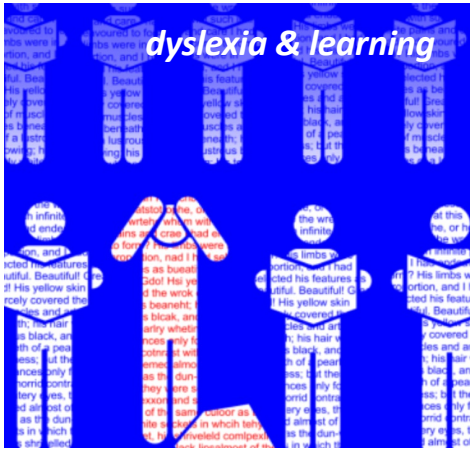


Jane Blackford – research +

curling • cars • cake • kayaks • dyslexia • **learning • materials**





Key information:
Course Guide, Guide to activities for the week

Key information:
Course Guide, Guide to activities for the week

Course guide (c. 10-30 minutes)
The course guide sets out the structure and content for the Materials 2 course. Take time to read it and get familiar with the contents.

Take time to read the course guide

The guide has the following sections:

1. Overview of the Course
2. Developing your own **materials toolbox:**
   WHAT, **HOW**, and **Resources**
3. Course Outline
4. Assessments
5. Course delivery
6. How the current course was created, shared values*, asking questions and a philosophy of pedagogy

1. Overview of the Course

The **aim** of the course is to provide a broad introduction to the materials used in engineering, their properties, and structures.

Materials are at the core of all disciplines of engineering. Engineers are better engineers when they have an awareness and understanding of the properties of materials. Science gives us a framework for understanding materials, within which we can include all classes of

Course outline

in Course Guide

3. Course Outline

Materials 2 is divided into three sections, as shown below. The course outline is intended to help you pace your studies.

Week	Topics	Other activities	
Section 1: Introduction and Materials Foundations			
1	• Why are materials important for engineers? • Classification of materials. • What are you going to study in this course? • Introduction to your building own **materials toolbox.** • How to learn and engage with the course		
Section 2: Properties and Microstructure How do things behave and why? The building blocks for using and understanding materials			
2	Properties: • What are material properties? • How do we find material property data (tests, resources, Ashby materials section chart)? • Testing for mechanical properties; what happens inside the material as it is deformed?	Lab *	
3	Small scale structure (microstructure): • Structures on different length scales • Links between everyday observations, properties, material classes, and small scale structures. • As an engineer, which structures are essentially fixed, and which can you change?		Granta *
4 – 5	Small scale structures of metals, ceramics and polymers • Classifications of metals, ceramics and polymers. • The small scale structure of metals, ceramics and polymers and links to their behaviour. • What makes alloys stronger than pure metals?		
5 – 6	Phase Diagrams • What are phases in materials? • Use phase diagrams to understand metallic alloy microstructure and properties.		
Section 3: Materials Stories, and Materials Selection			
7-10	Examples of applications of materials. Deepening your understanding of materials and making connections through case studies. • Concrete and timber. • Composite materials. • The Challenger disaster and Liberty ships. • Materials selection.		
11	Revision		

* Other activities during the course:

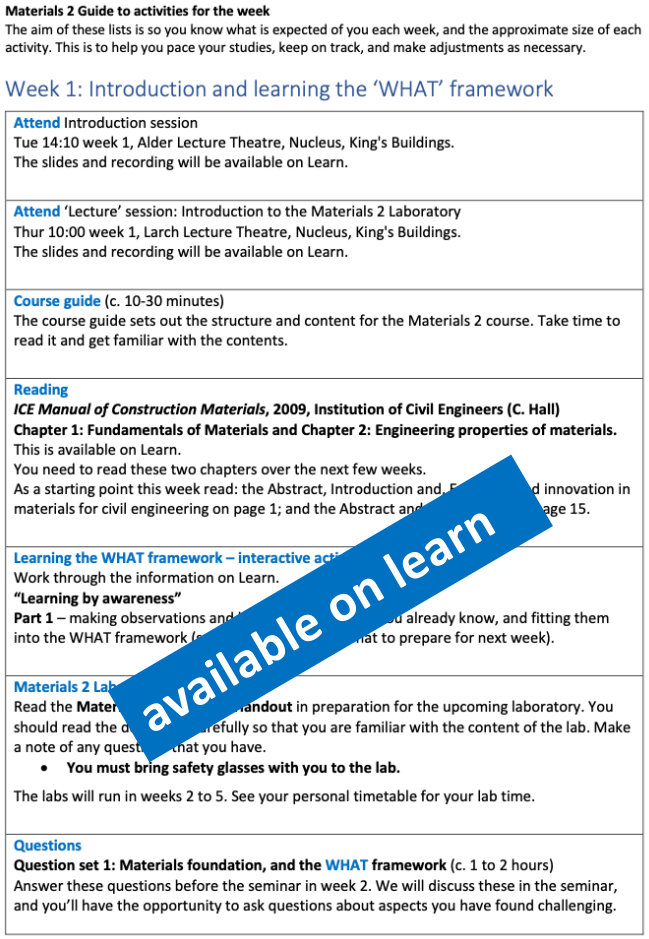
- You will have a **Materials 2 lab** scheduled at some point during Weeks 2 to 5. This will appear in your personal timetable.
- You will be introduced to **Ansys Granta materials software** during Materials 2.

read this more slowly in the course guide

Key information:
Course guide, Guide to activities for the week

Materials 2 Guide to activities for the week

- The aim of these lists is so you know what is expected of you each week, and the approximate size of each activity. This is to help you pace your studies, keep on track, and make adjustments as necessary.
- Issued at the start of each week



Materials 2 Guide to activities for the week

The aim of these lists is so you know what is expected of you each week, and the approximate size of each activity. This is to help you pace your studies, keep on track, and make adjustments as necessary.

Week 1: Introduction and learning the 'WHAT' framework

Attend Introduction session
Tue 14:10 week 1, Alder Lecture Theatre, Nucleus, King's Buildings.
The slides and recording will be available on Learn.

Attend 'Lecture' session: Introduction to the Materials 2 Laboratory
Thur 10:00 week 1, Larch Lecture Theatre, Nucleus, King's Buildings.
The slides and recording will be available on Learn.

Course guide (c. 10-30 minutes)
The course guide sets out the structure and content for the Materials 2 course. Take time to read it and get familiar with the contents.

Reading
***ICE Manual of Construction Materials*, 2009, Institution of Civil Engineers (C. Hall)**
Chapter 1: Fundamentals of Materials and Chapter 2: Engineering properties of materials.
This is available on Learn.
You need to read these two chapters over the next few weeks.
As a starting point this week read: the Abstract, Introduction and
materials for civil engineering on page 1; and the Abstract and

Learning the WHAT framework – interactive
Work through the information on Learn.
"Learning by awareness"
Part 1 – making observations and
into the WHAT framework (

Materials 2 Lab
Read the **Mater** **handout** in preparation for the upcoming laboratory. You should read the d refully so that you are familiar with the content of the lab. Make a note of any quest that you have.

- **You must bring safety glasses with you to the lab.**

The labs will run in weeks 2 to 5. See your personal timetable for your lab time.

Questions
Question set 1: Materials foundation, and the WHAT framework (c. 1 to 2 hours)
Answer these questions before the seminar in week 2. We will discuss these in the seminar, and you'll have the opportunity to ask questions about aspects you have found challenging.

available on learn

Your **Feedback** to us

Please give us feedback whenever appropriate, it help us develop the course and for you and for future students

Change this year: new whole class ‘lecture’ sessions on many Thursdays.

The current third year Chem Eng students, in retrospect, wished they had engaged more consistently during the course – at the outset it seemed easy. When they came to revise for the exams they discovered it wasn’t.

Seminars

Tuesday morning each week (will appear in your timetables)

The purpose of the seminars is to create in-person connection to allow us all to engage with the course.

The **key thing with seminars is that you *show up***, and **to get the most from them** you need to engage with the course materials and questions **before** the seminar, and review the comments and answers **afterwards**.

HOW, IN ACTION

<u>for all involved in the course</u>

1. **Show up**
2. **Bring curiosity and care**
3. **Focus on what matters**

This is core to how we all engage with the course –
in seminars and for doing <u>any</u> activity on the course

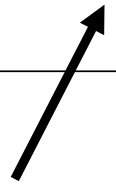
HOW, IN ACTION

for all involved in the course

1. Show up

2. Bring curiosity and care

3. Focus on what matters



WHAT – content, and

HOW – what works for you today?

speaking, 'simply' listening and absorbing what's going on

- this doesn't have to be the same each week

Materials 2 course delivery team

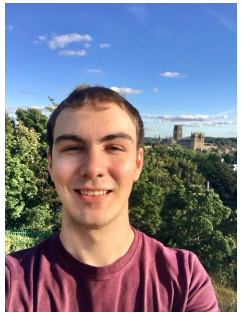
Dr Jane Blackford, course organiser, Mechanical Engineering

Dr Tom Reynolds, co-teaching course, Civil Engineering

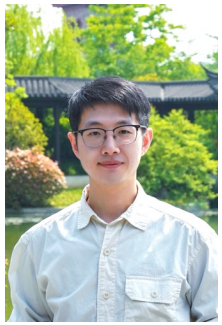
Tutors and demonstrators for the course, all are PhD students, they have first degrees in Civil, Chemical and Mechanical Engineering, Chemistry and Physics

Tutors and demonstrators

Vinayak



Thomas



Pengxu

Tiziano

Alex

Supreeth

Ali

Dev

Sithija

Gabriele

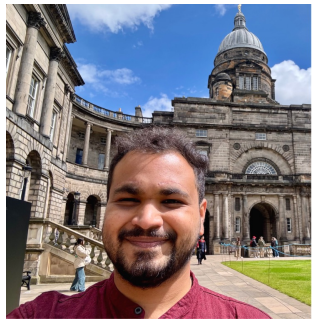
Kacper

Seamus

Ronald

Luxi

Haris

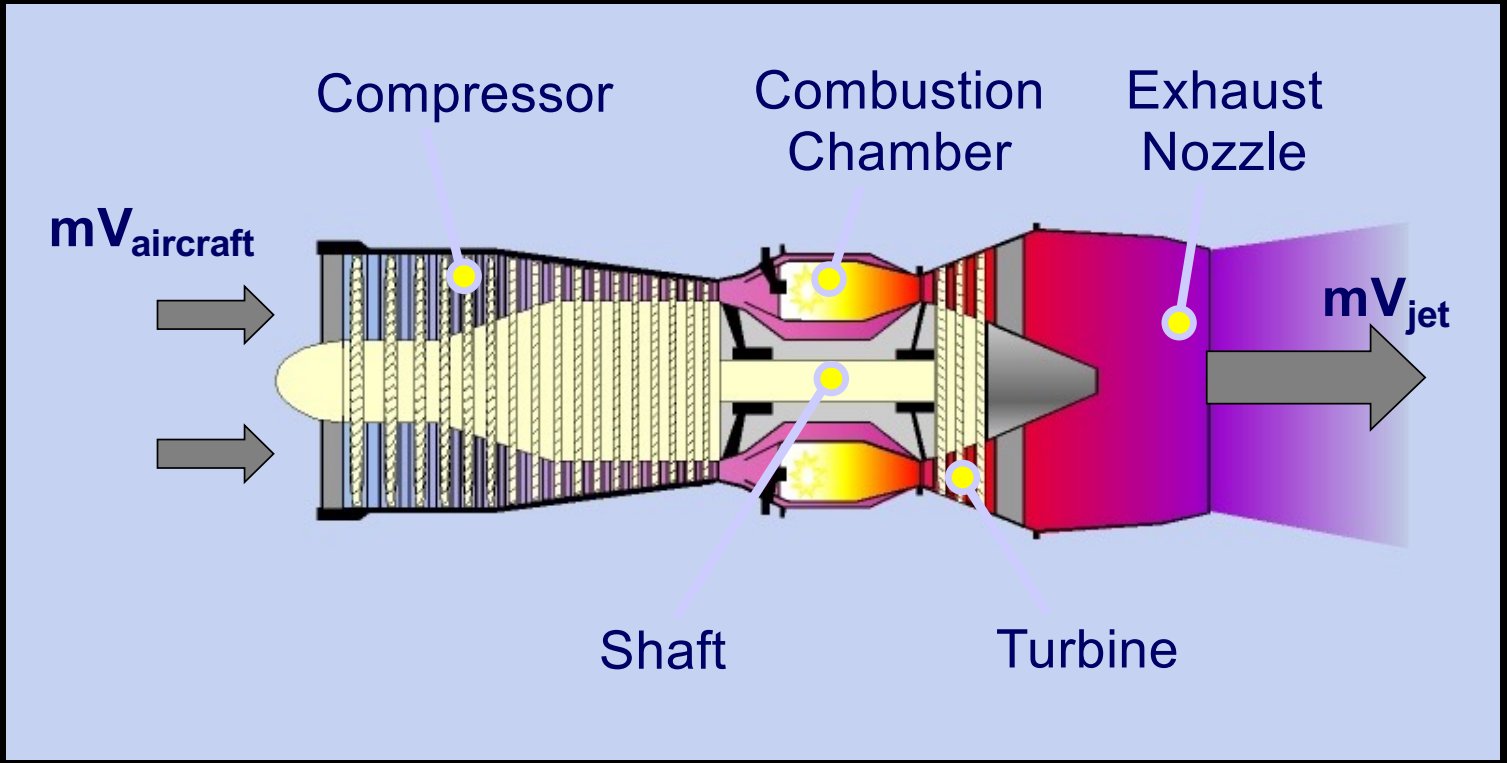


Aditiya

plus Abbas, Arun and Miguel


BRITISH AIRWAYS
BusinessAir
www.flightglobal.com

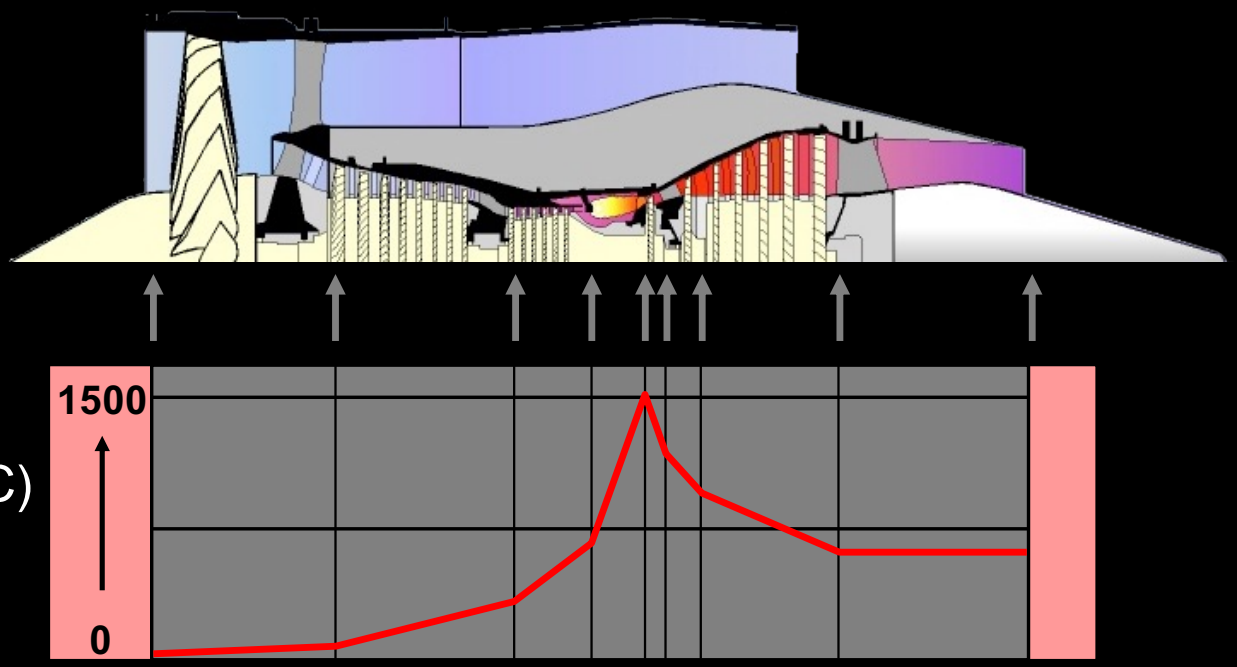
Jet engine layout



From Cervenka, Rolls Royce, 2000

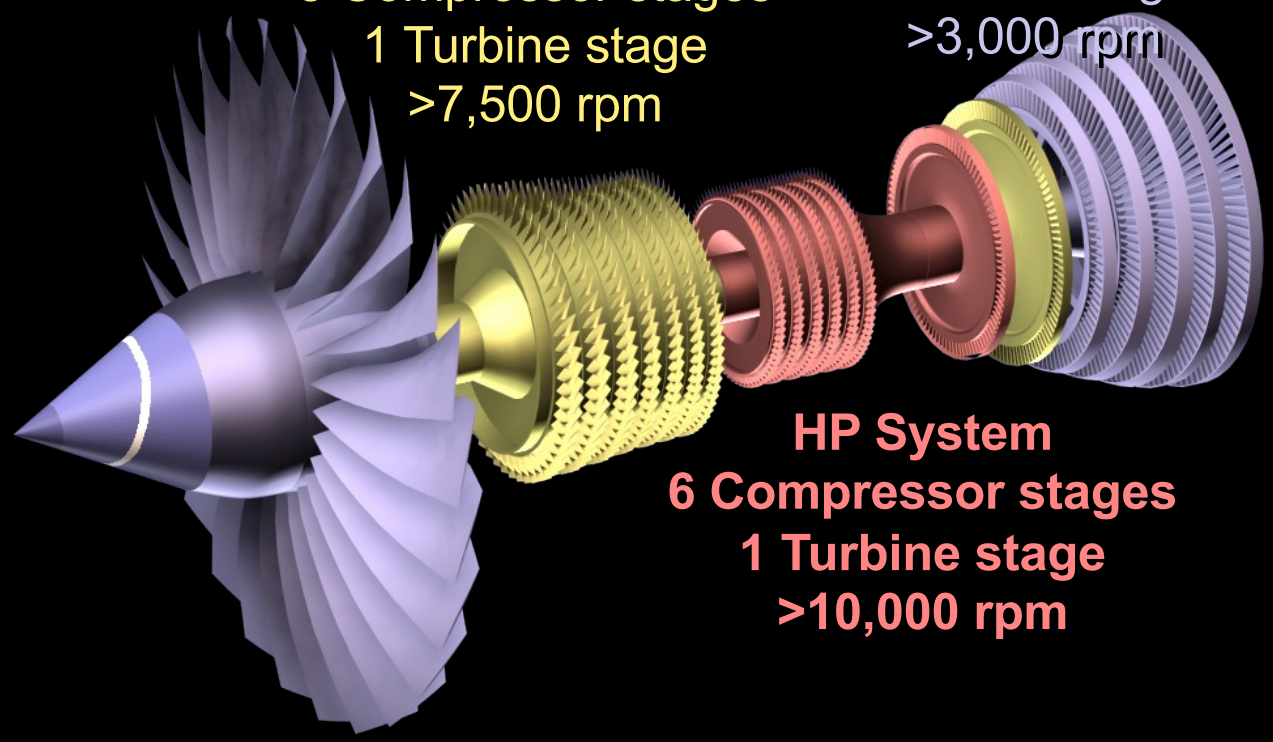
What are the operating conditions inside a gas turbine in a jet?

Temperature



From Cervenka, Rolls Royce, 2000

Mechanical forces



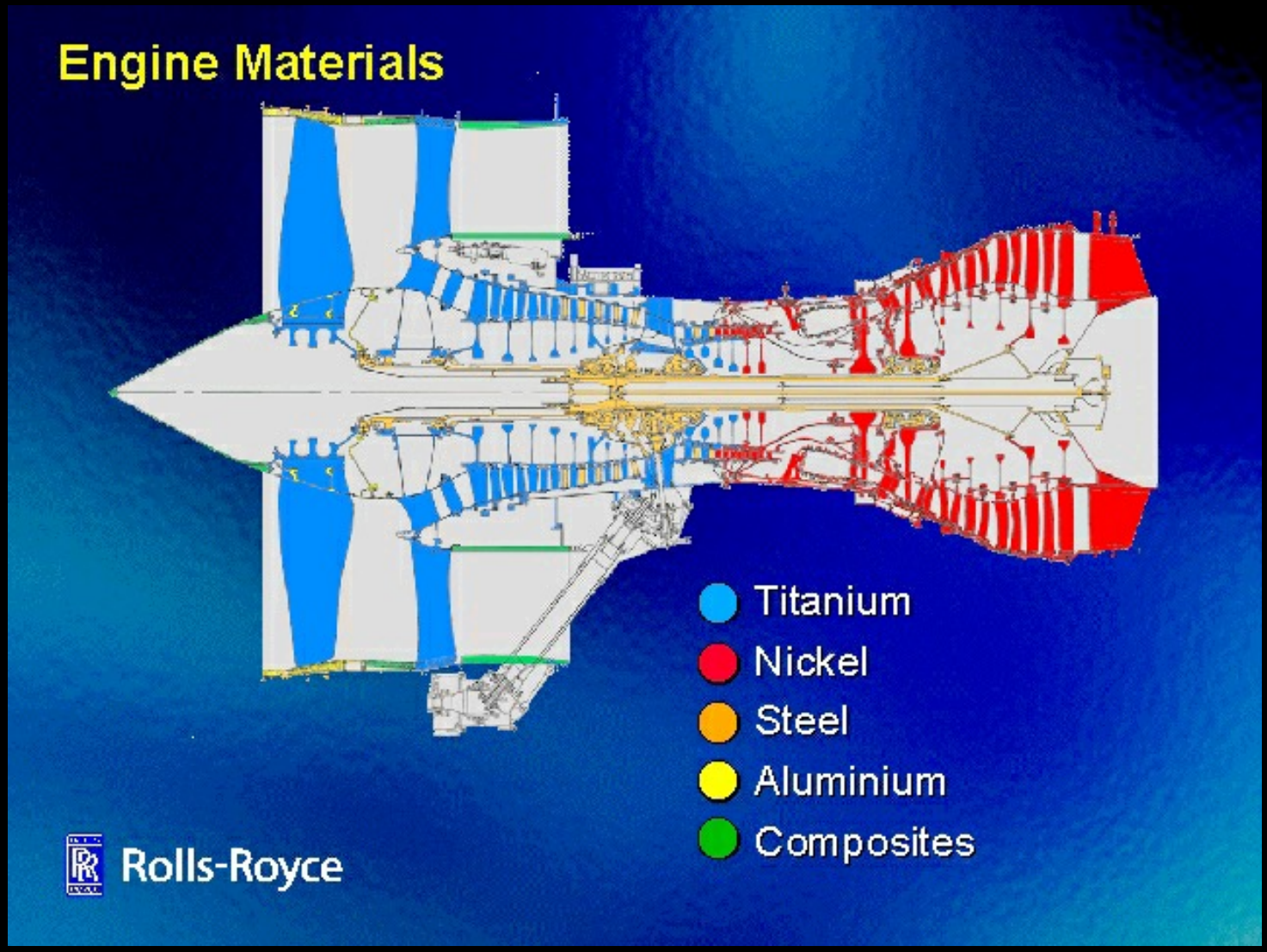
From Cervenka, Rolls Royce, 2000

Materials in a turbine engine need to withstand high temperatures, complex mechanical forces and resist oxidation and corrosion

$\Rightarrow$ We need materials with appropriate

mechanical, thermal, and chemical properties

To withstand creep, fatigue, thermomechanical fatigue, oxidation, hot corrosion, and erosion.



From Cervenka, Rolls Royce, 2000

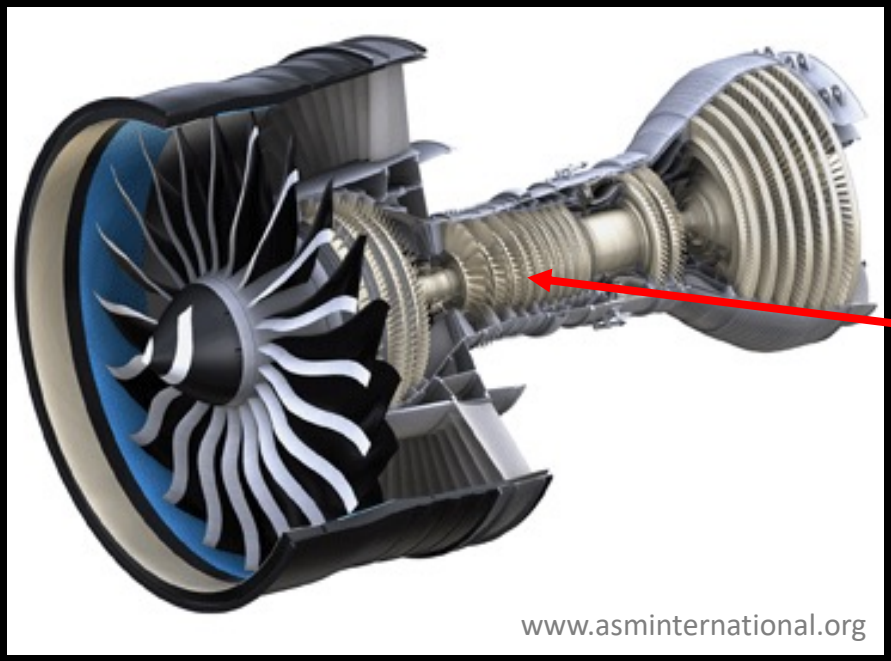
Nickel superalloy turbine blade

Nickel superalloy e.g. IN713

Chemical composition:

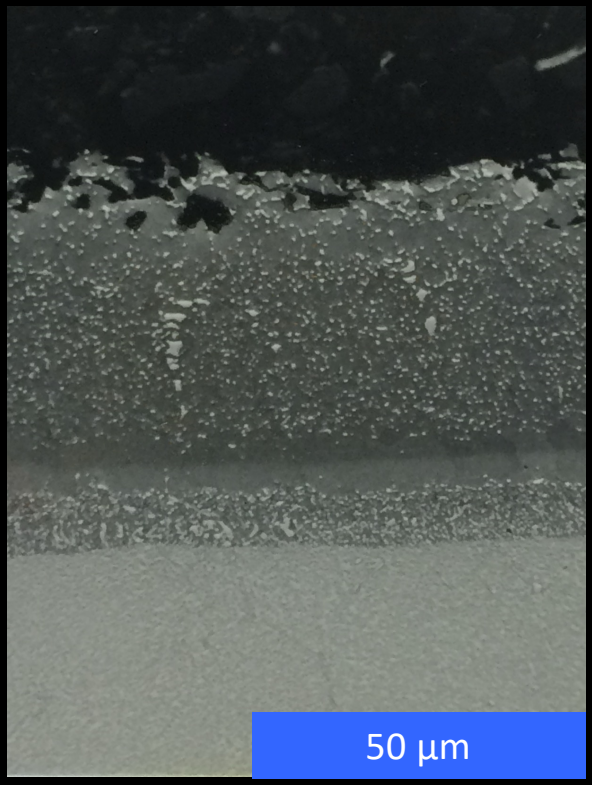
12.50 Cr, 6.10 Al, 4.20 Mo, 2.20 Nb+Ta, 0.8 Ti, 0.10 Zr, 0.08 Co, 0.12 C, 0.012 B, lap* Fe, lap* Si, lap*Mn, lap* Cu, the rest is Ni (all in weight %).

lap* = low as possible


www.asminternational.org

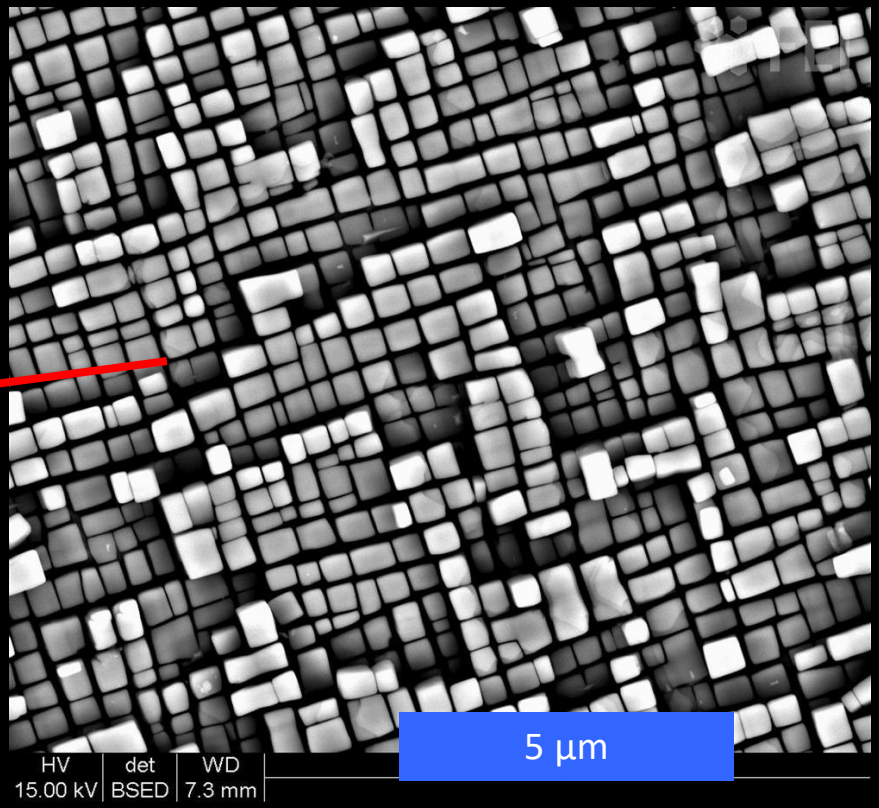

nickel superalloy turbine blade

nickel superalloy turbine blade



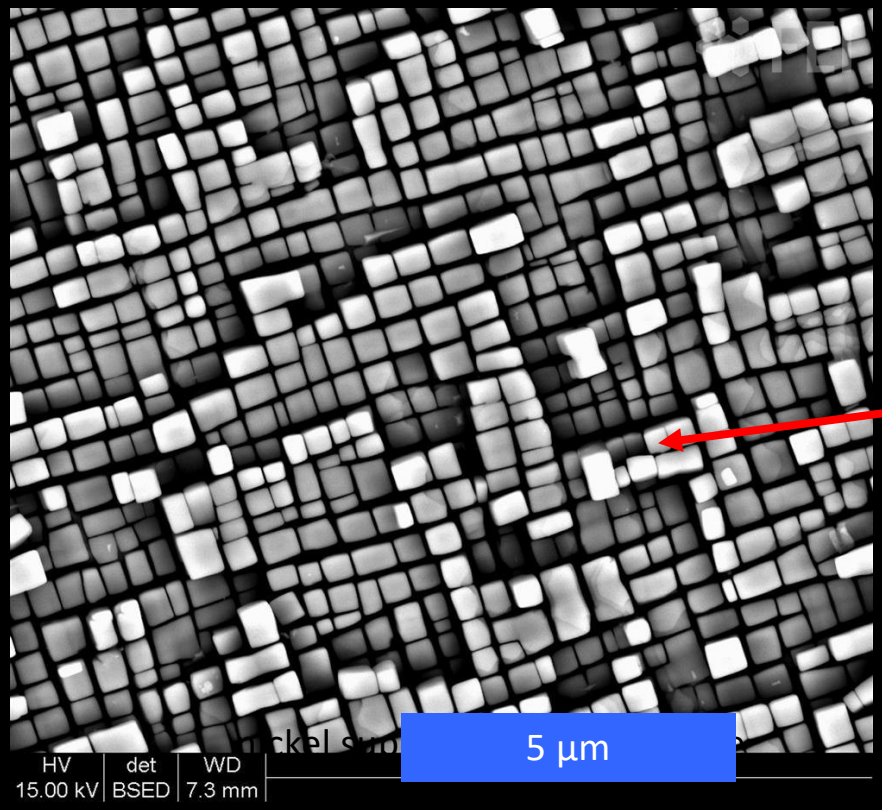
microstructure of coating
in cross section

nickel superalloy turbine blade

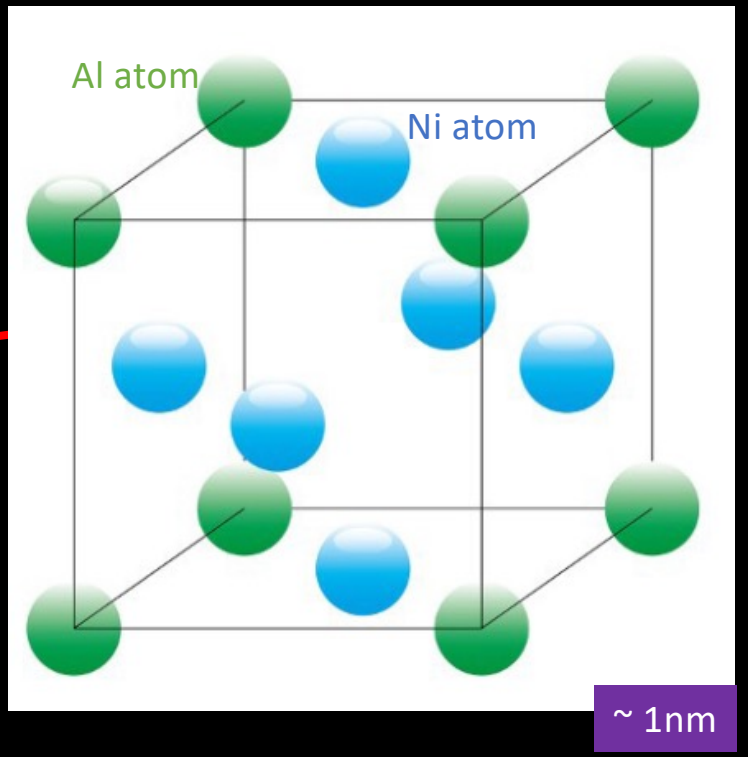


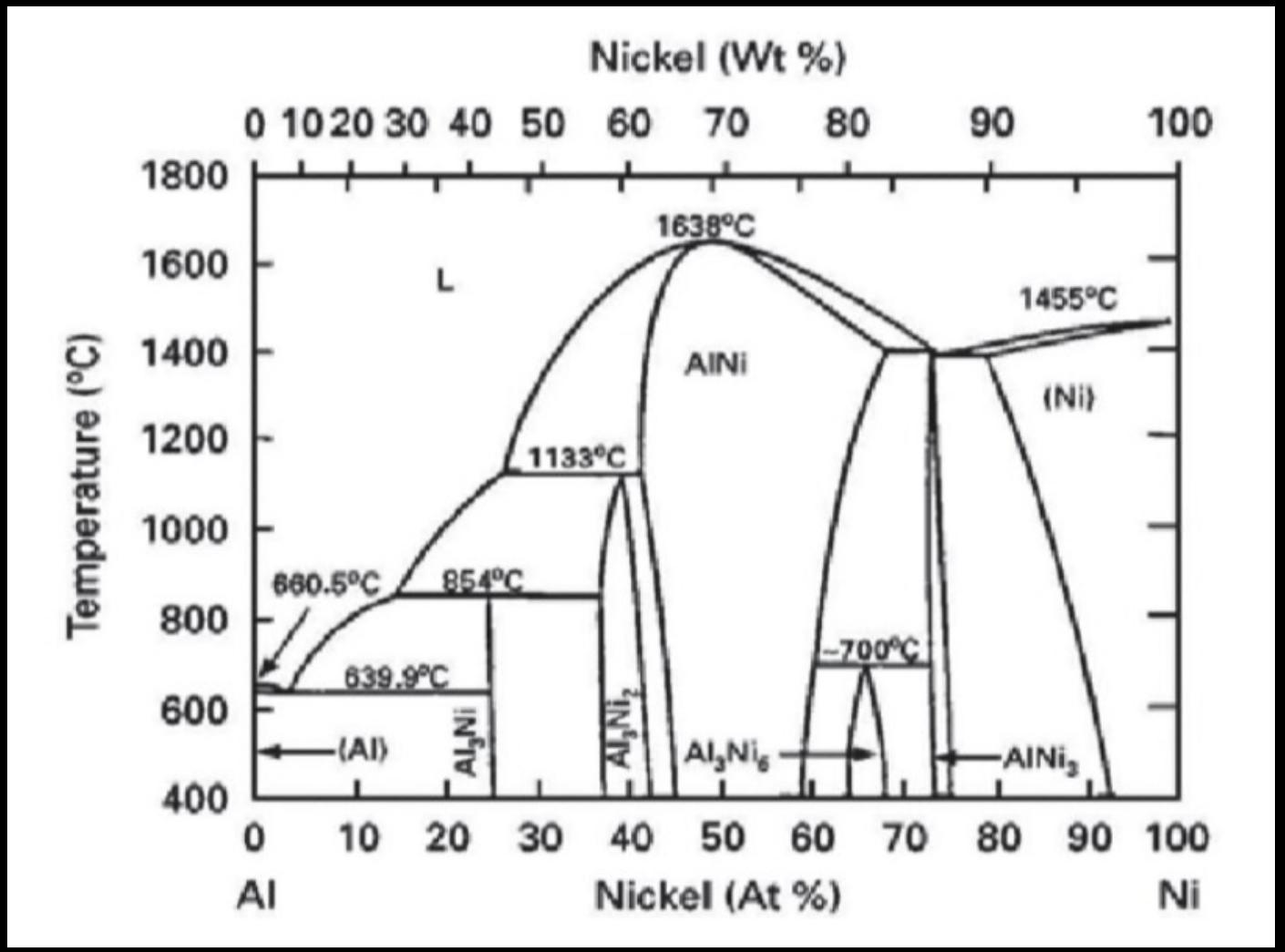
microstructure of blade

www.flickr.com/photos/fei_company/14160120920/

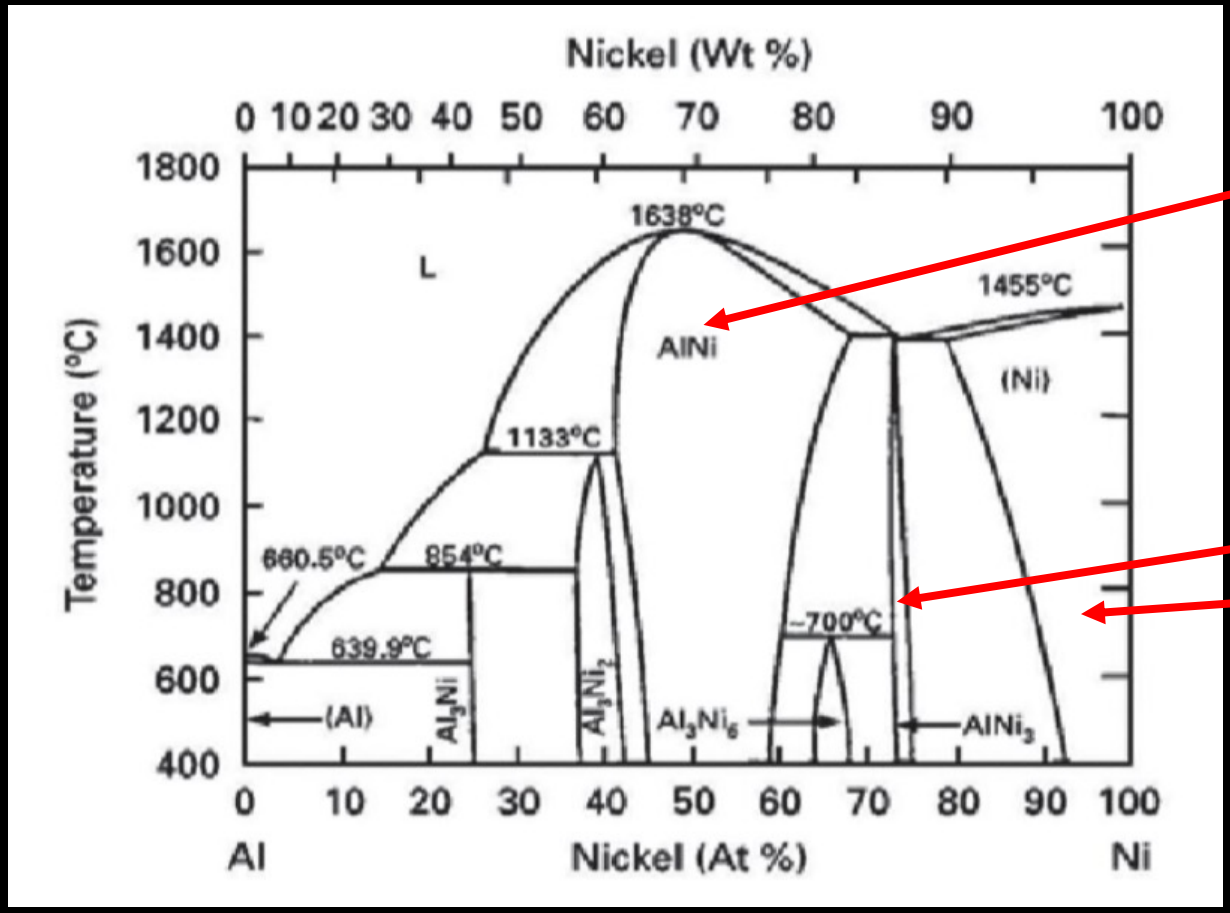


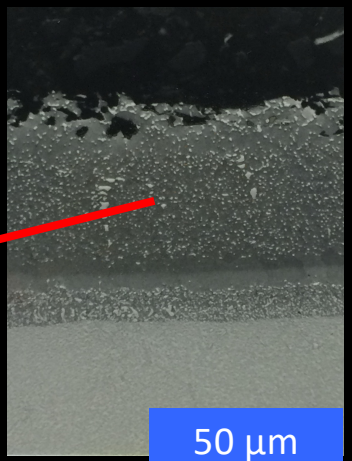
microstructure of blade



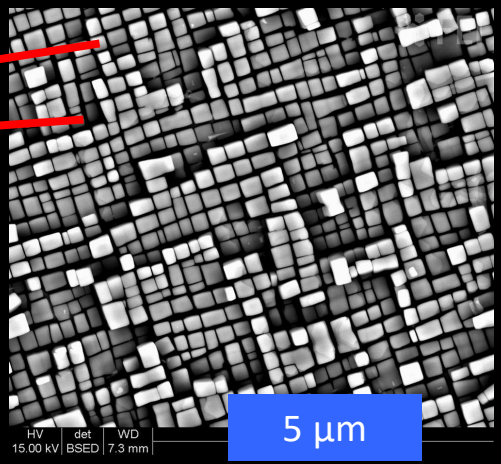


aluminium-nickel phase diagram





microstructure of coating



microstructure of blade

processing

investment casting and heat treatment

and coating processes

“Superalloys as a class constitute the currently reigning aristocrats of the metallurgical world. They are the alloys which have made jet flight possible, and they show what can be achieved by drawing together and exploiting all the resources of modern physical and process metallurgy in the pursuit of a very challenging objective.”

from R.W. Cahn *The coming of materials science*, 2001.

WHAT Framework, for high temperature turbine blade **Materials**	
Classification	Nickel superalloy, based on Ni+Cr+Al, e.g. IN713
Properties	Mechanical, thermal & chemical high temperature strength, fracture toughness, creep, fatigue, thermomechanical fatigue, oxidation, hot corrosion, erosion
Processing	Casting, heat treatment, coating processes
Small scale structure (microstructure)	Grain structure, coating structure (based on NiAl), Ni_3Al cuboid shape strengthening precipitates in blade, packing of Ni & Al atoms at atomic scale
Applications	Jet engines also used in industrial power generation turbines

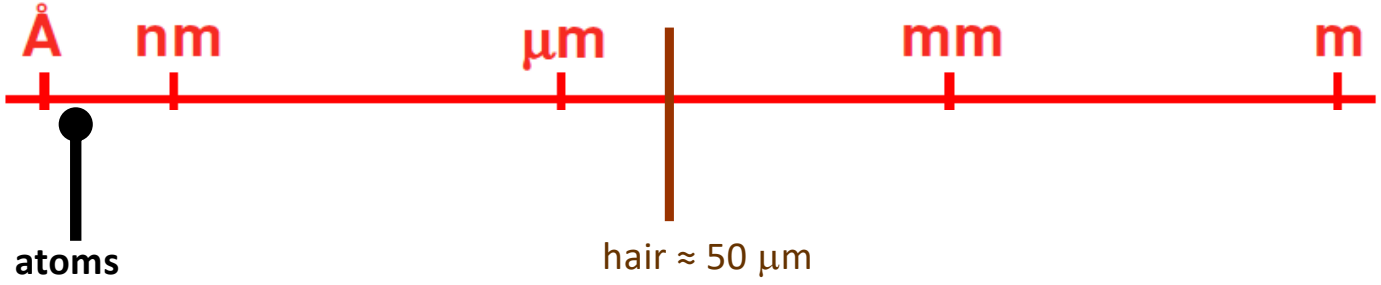
WHAT Framework
Materials
- **Classifications**
- **Properties**
- **Small scale structure** (microstructure)
- Processing / manufacturing
- **Applications**

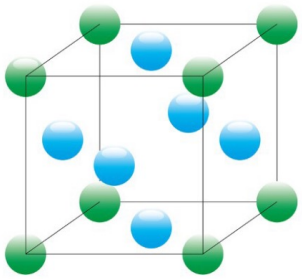
Structure on different scales

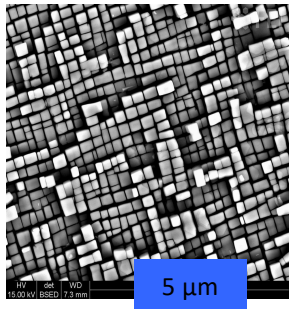
WHAT Framework

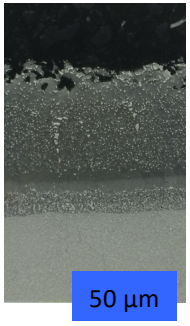
Materials

- Classifications
- Properties
- **Small scale structure (microstructure)**
- Processing / manufacturing
- Applications









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www.rolls-royce.com

WHAT Framework

Materials

- **Classifications**
- **Properties**
- **Small scale structure** (microstructure)
- Processing / manufacturing
- **Applications**

Everything in materials science and engineering can be fitted into this framework. It provides the context for the understanding of materials that you will develop during this course, and in the future.

WHAT Framework

Materials

- **Classifications**
- **Properties**
- **Small scale structure** (microstructure)
- Processing / manufacturing
- **Applications**

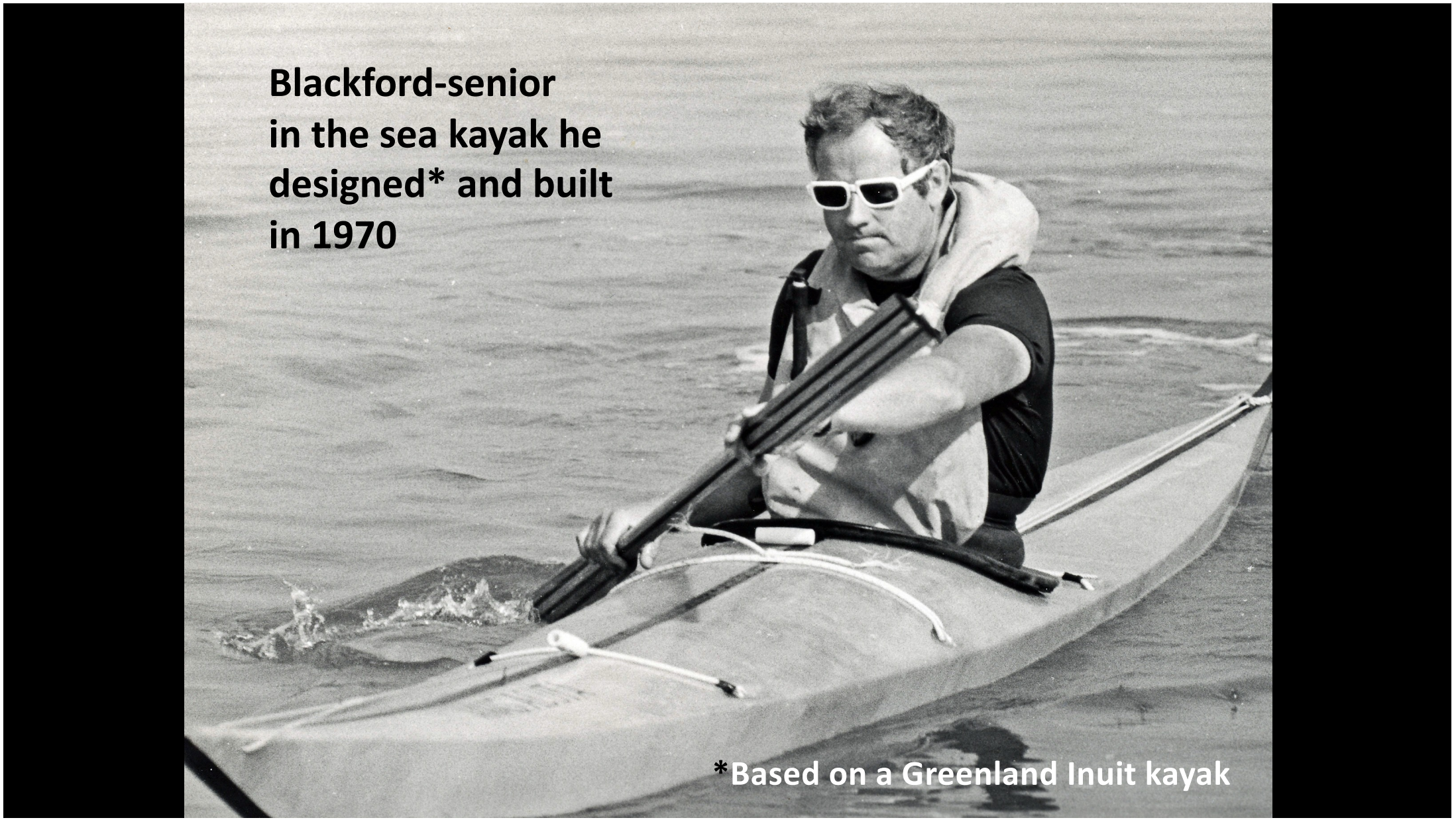
"As to methods, there may be a million and then some, but principles are few. The man who grasps **principles** can successfully select his own methods. The man who tries methods, ignoring principles, is sure to have trouble."

Harrington Emerson c. 1911

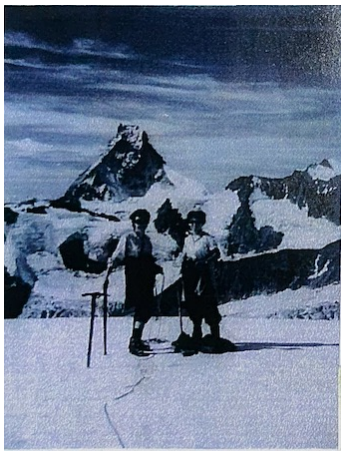
Introduction to the teaching team

Professor Geoffrey Greenwood –
my final year project supervisor FREng & FRS

Blackford-senior in 2016 ‘making time for play’


Blackford-senior
in the sea kayak he
designed* and built
in 1970
*Based on a Greenland Inuit kayak

Me (!) in a miniture version of the sea kayak



Alice, Margaret (my mum), Maureen

“never lose your sense of wonder”

Alice Palmer

Changing times, now cf. 100 years ago implications for teaching and learning

The World and Education are changing
now cf. 100 years ago no devices, no internet … no Covid-19

Environment, sustainability, societal and ethical issues matter *(jb opinion)*

Now we have near-instant access to excessive information (beyond textbooks and lectures)
Learning to find ways to deal with this is a key skill – this links to knowing about **resources** and understanding how they can be used

Core skills / learning for engineers, for materials :: core minimal course
-the need to memorise most stuff is gone
-understanding how to use information to **do** useful stuff
-being able to determine **quality** is a core skill

What's important for engineers and engineering students in 2020+?

#start-where-at

The Guardian
Newspaper of the year

Brief letters

Wed 28 Dec 2011 21.00 GMT

● Outside Rome, advertising has been out of control for years (Romans revolt over billboard jungle, 27 December). Ogden Nash put it succinctly: "I think that I shall never see / A billboard lovely as a tree. / Perhaps unless the billboards fall, / I'll never see a tree at all."

Alice Palmer

Appleby-in Westmorland, Cumbria

materials • place • poetry • billboards • trees … wood … timber • *our* environment • sustainability

HOW we do what we do matters

“never lose your sense of wonder”

materials & learning