



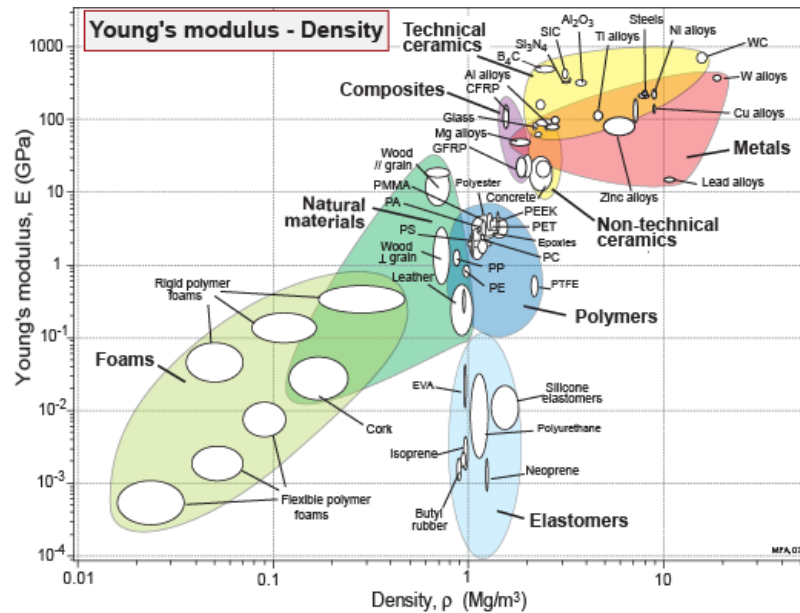
Aalto University  
School of Engineering

# MEC-E1070

# Selection of Engineering Materials

*Prof. Junhe Lian, Prof. Sven Bossuyt*  
*course assistant Zinan Li*

# Charts



- Exploring relationships: property charts
- Making charts
- Custom subsets, adding your own materials
- Report writing

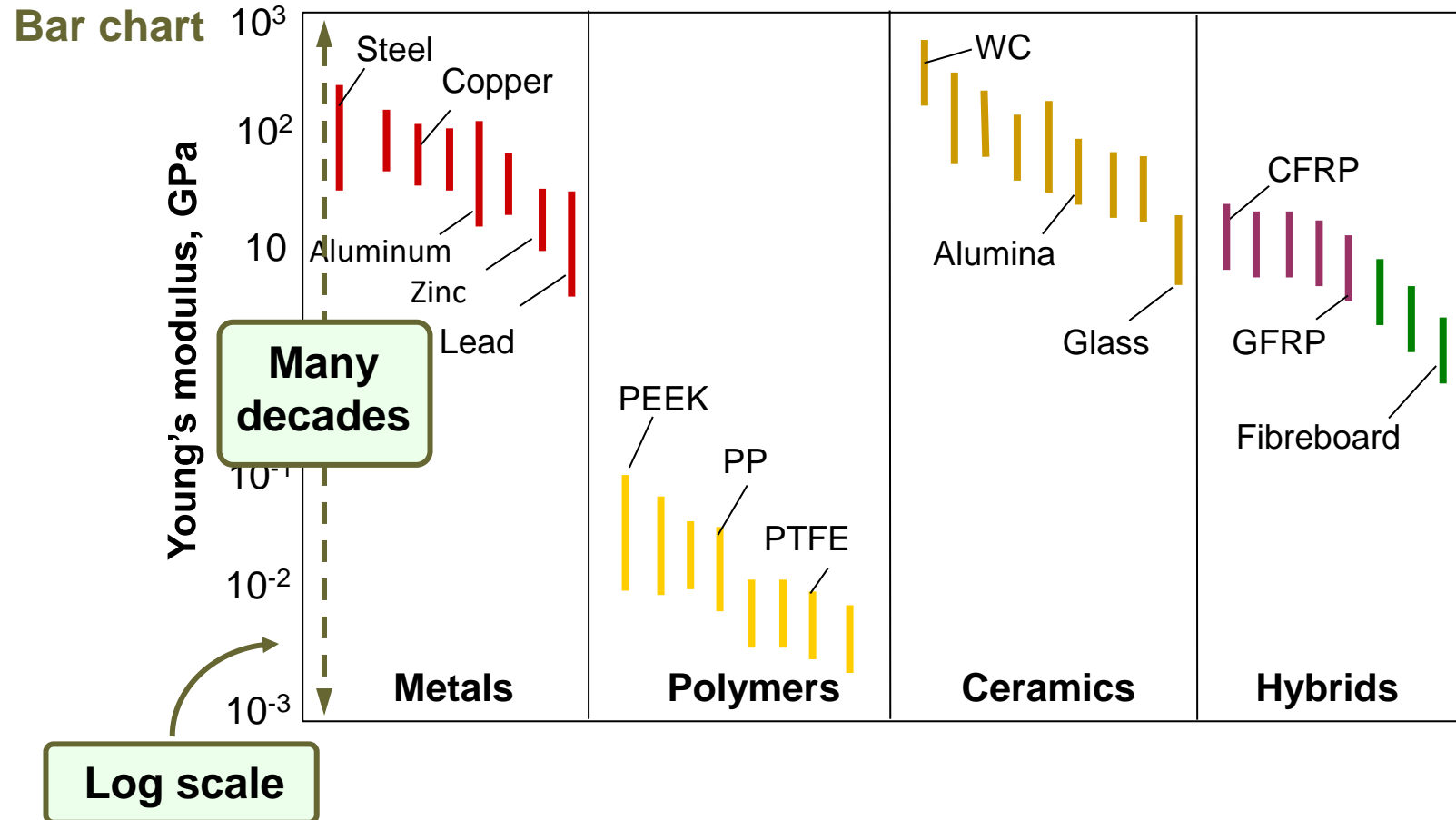
# Bar charts

Data sheets = numbers, words

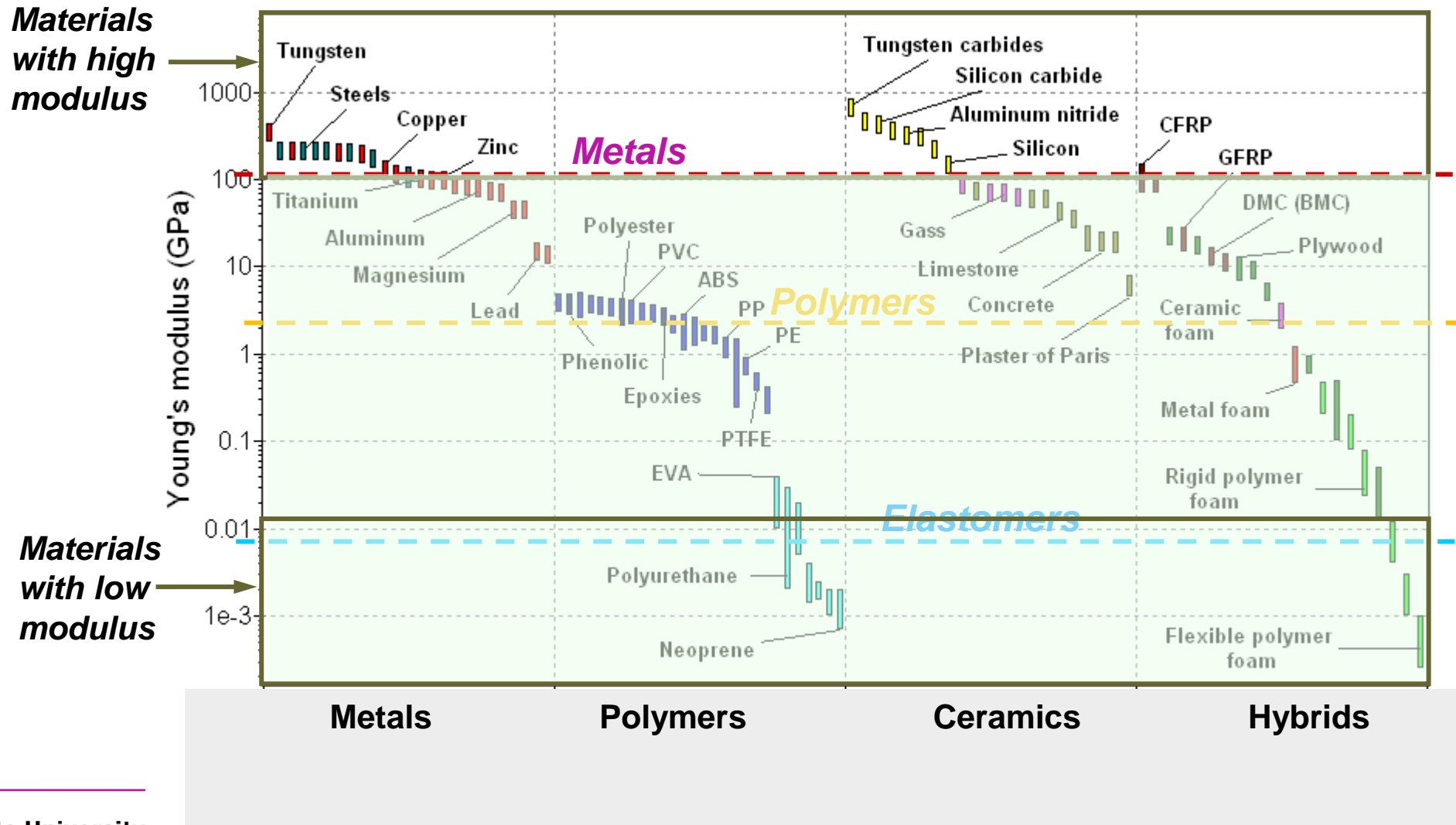
We want **meaning**



**Property charts**

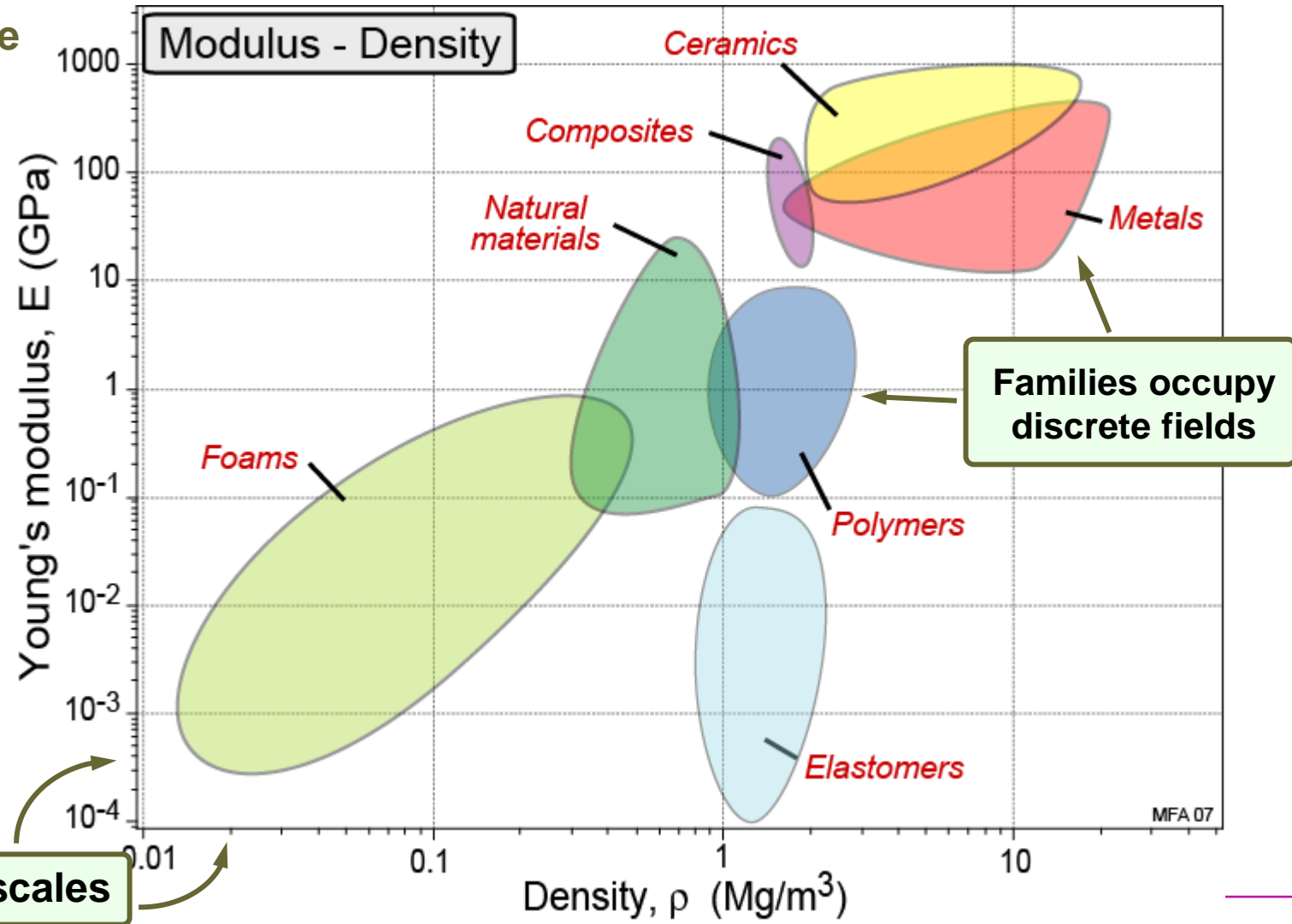


# Bar-chart created with *GRANTA EduPack*



# Bubble charts

Bubble  
chart



**A** **Aalto University**  
**School of Engineering**

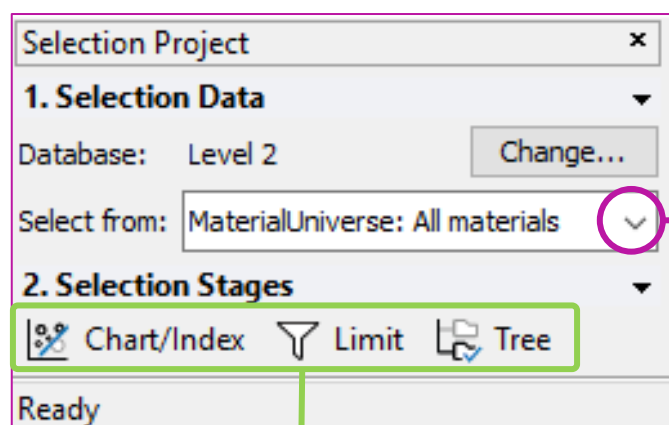
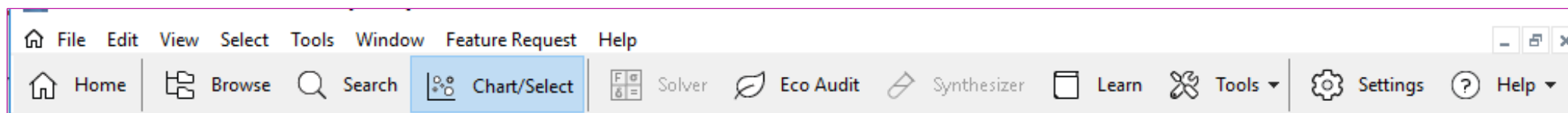


# Table chart

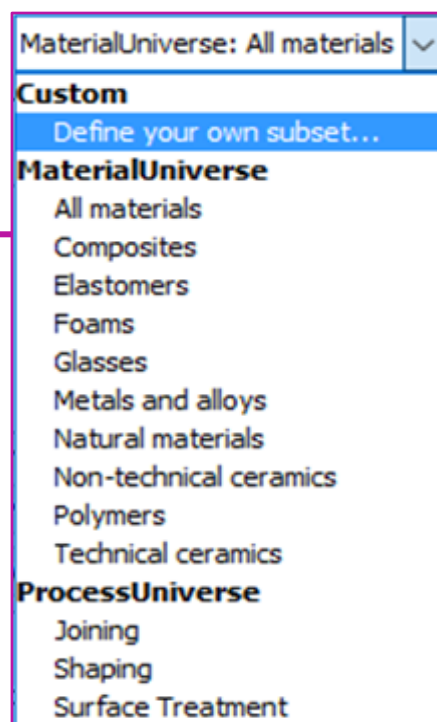
## Discrete data

Composites	Plastics
Foams	Non-technical ceramics
Metals	Technical ceramics
Elastomers	Natural materials

# Creating charts for selection

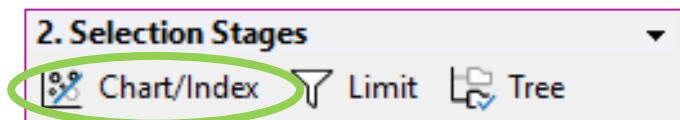
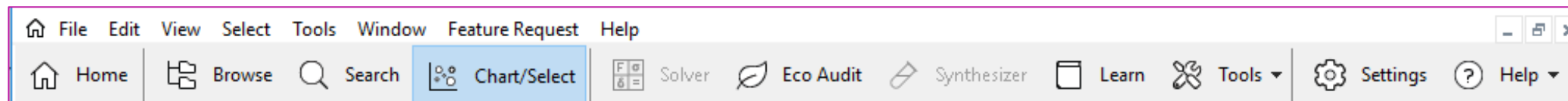


Plotting and selection tools





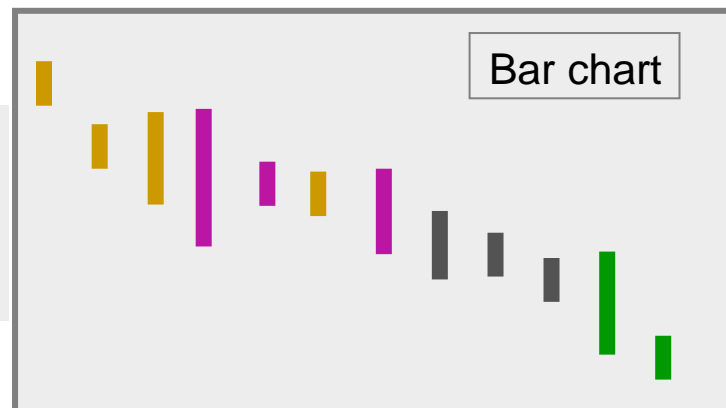
# Creating charts for selection



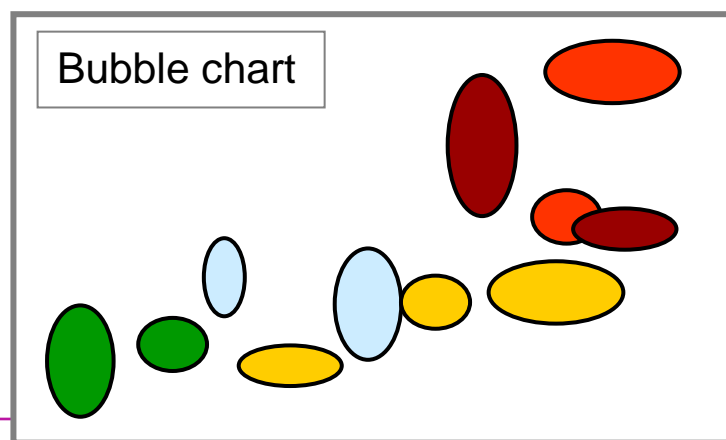
Choose:

X-Axis	Y-Axis
<b>List of properties</b>	
<ul style="list-style-type: none"><li>▪ Density</li><li>▪ Yield strength</li><li>▪ Young's modulus</li><li>▪ etc.</li></ul>	

Property



Property 1



Property 2

# Creating advanced charts for selection

File Edit View Select Tools Window Feature Request Help

Home Browse Search Chart/Select Solver Eco Audit Synthesizer Learn Tools Settings Help

2. Selection Stages

Chart/Index Limit Tree

Choose:

X-Axis Y-Axis

List of properties

Advanced

- Density
- Yield strength
- Young's modulus
- etc.

Modulus / Density

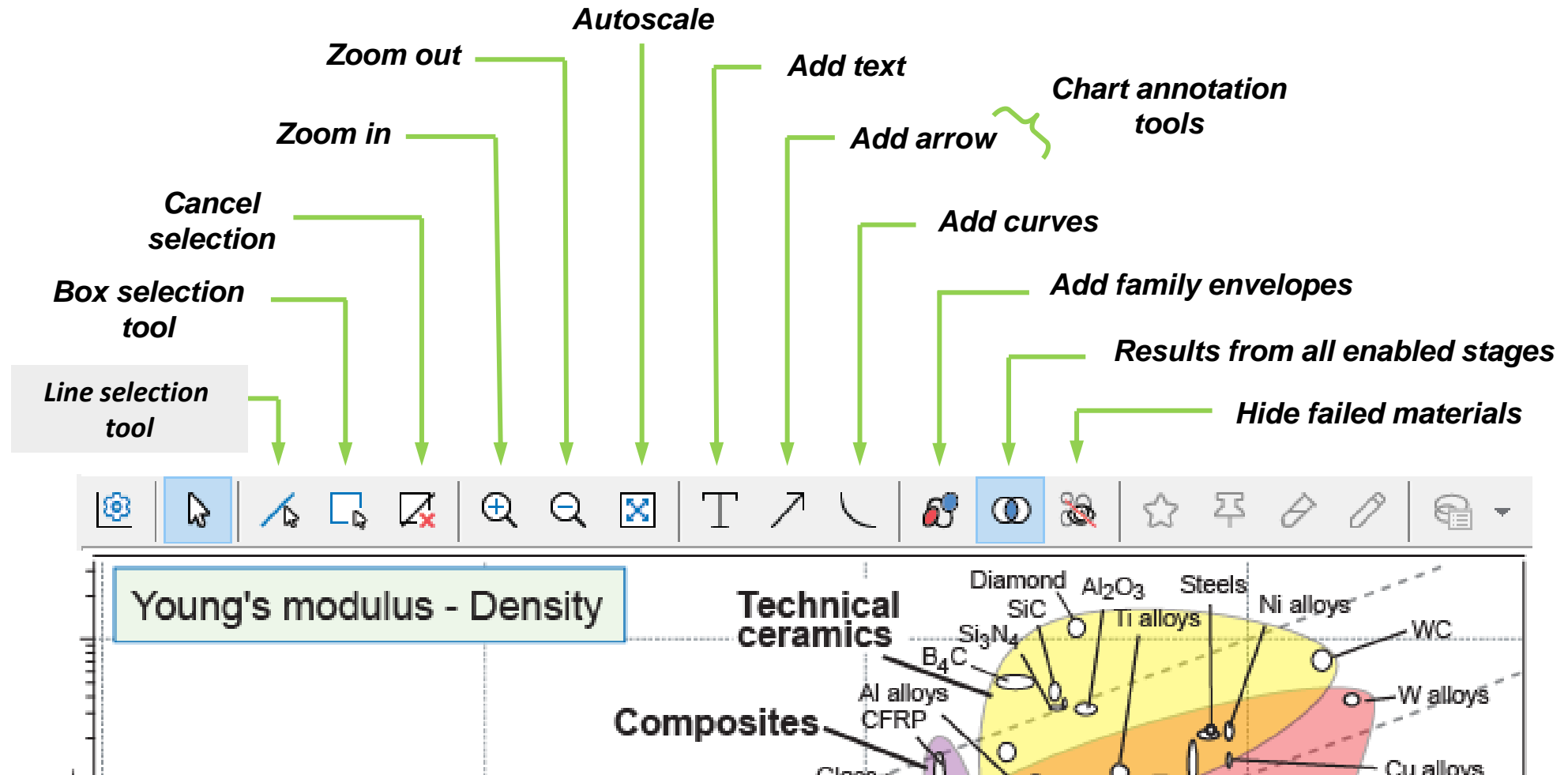
Bar chart

Bubble chart

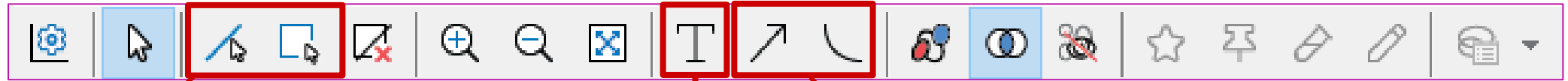
Yield strength / Density

- etc

# The chart-management tool bar



# The line, box and curve tools

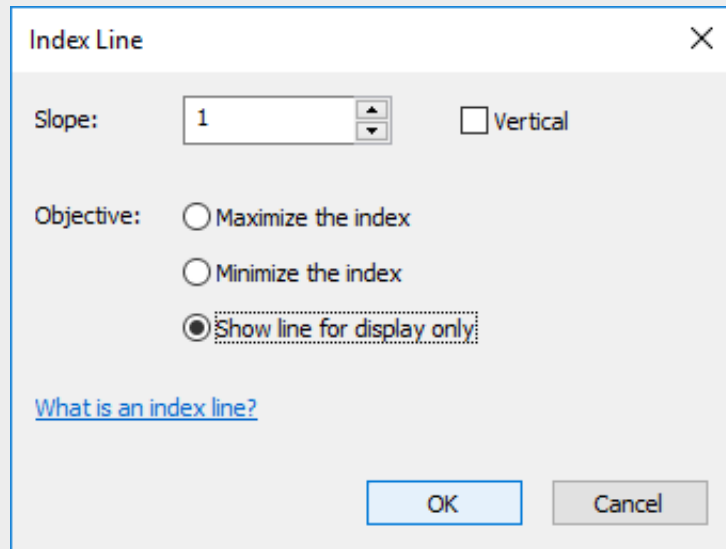


Add **boxes** and **lines**

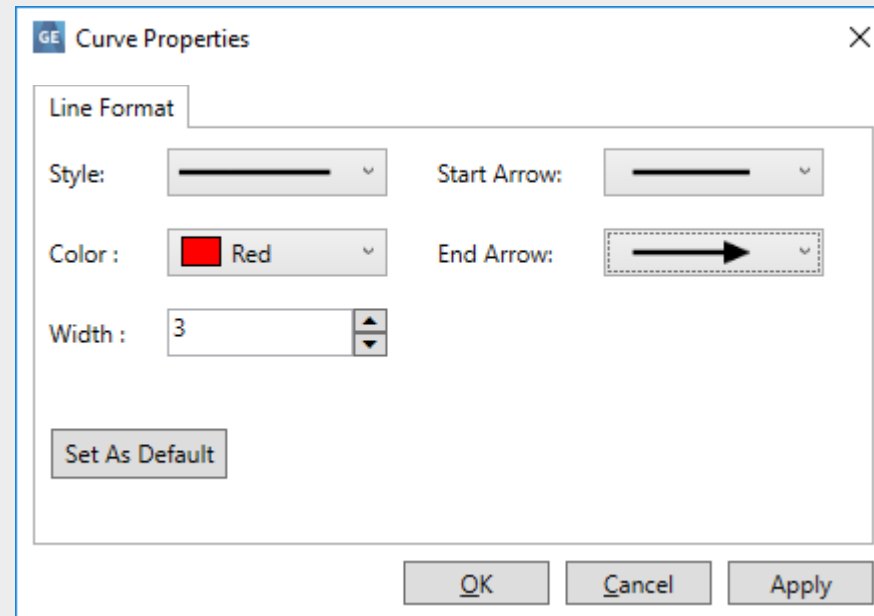
Add **text** to chart

Display **curves** and **arrows**

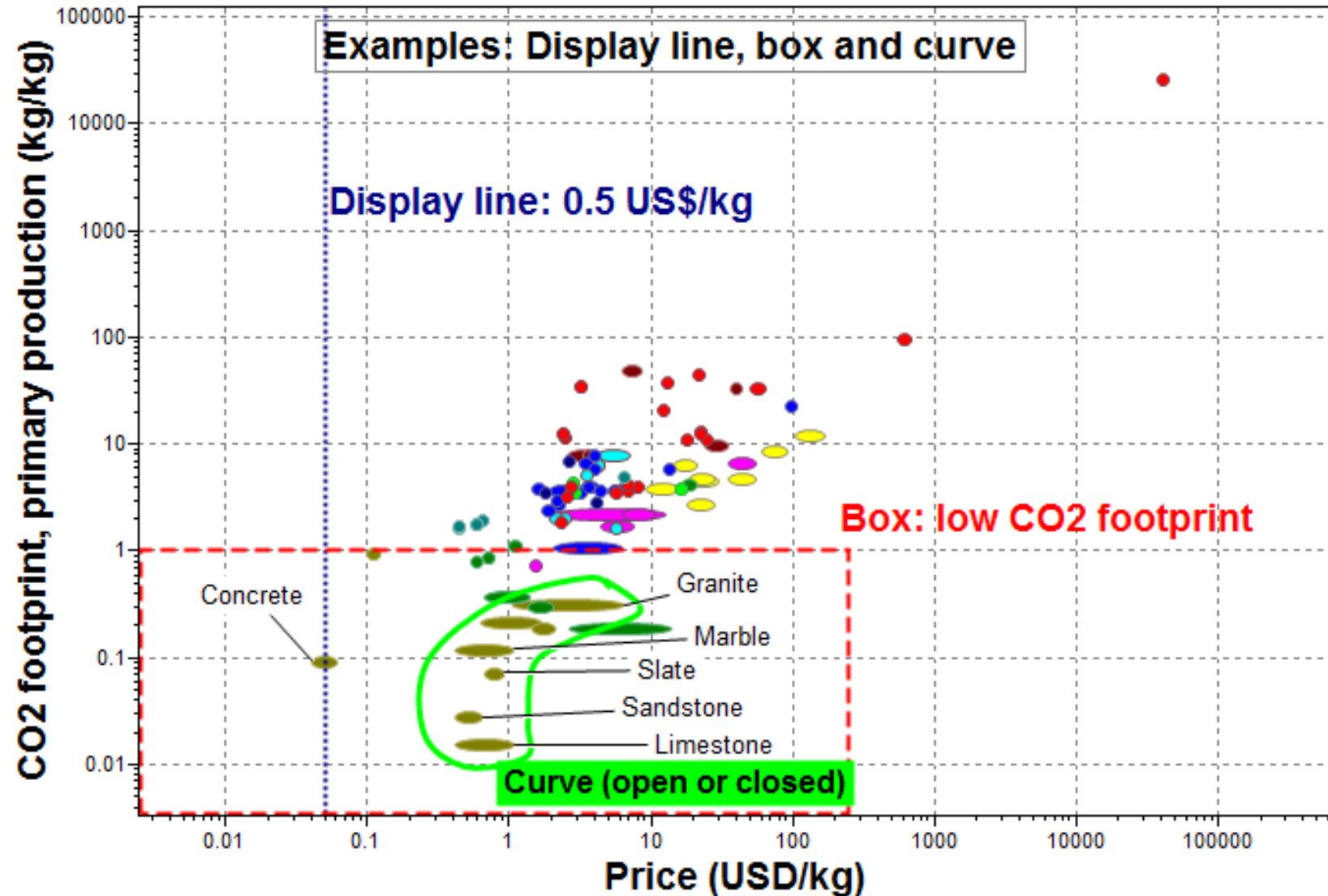
For annotation, select display only:



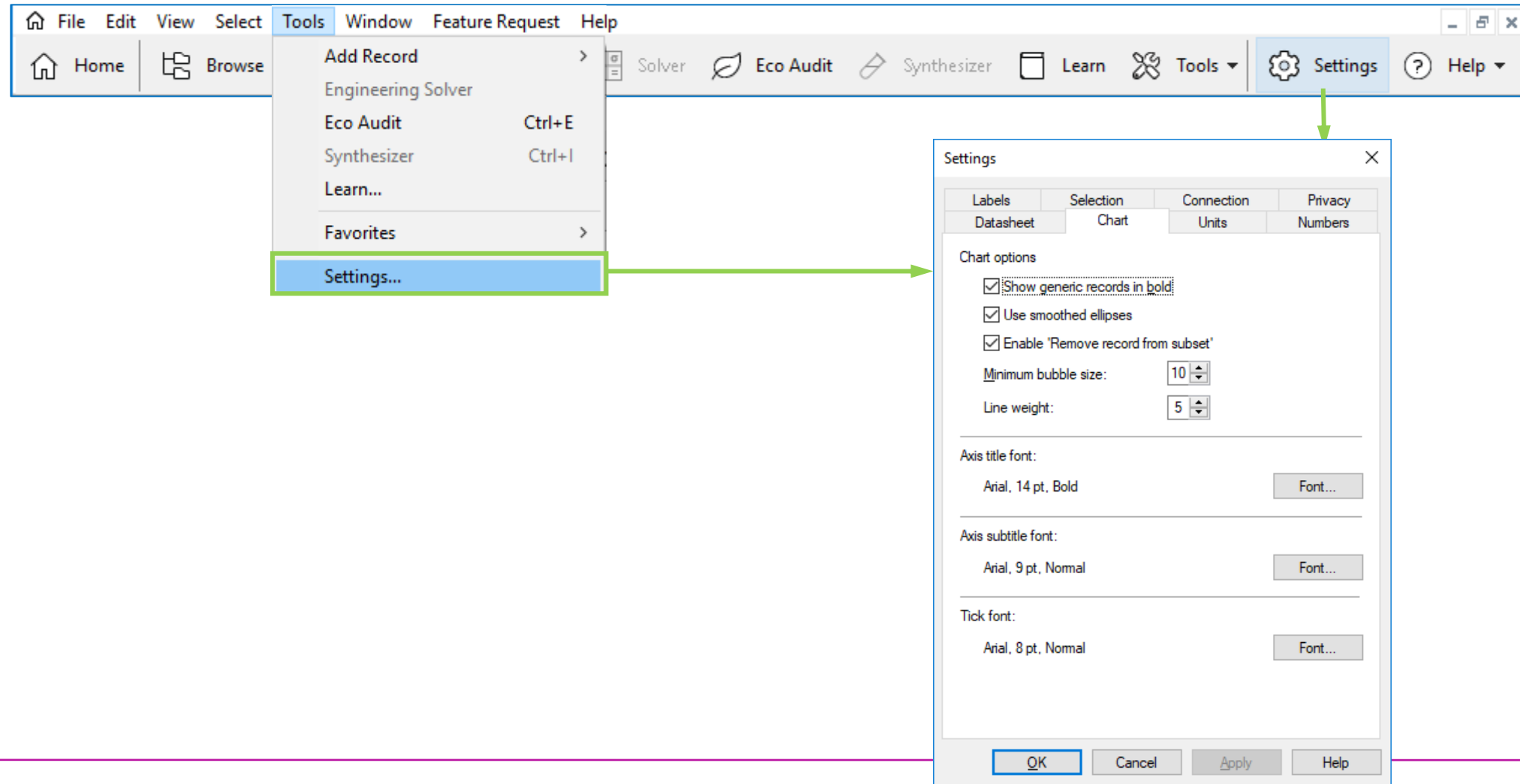
Right-click on line, box or curve to format:



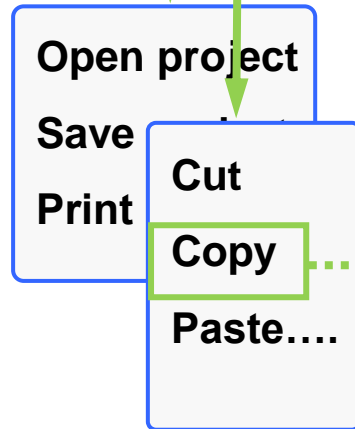
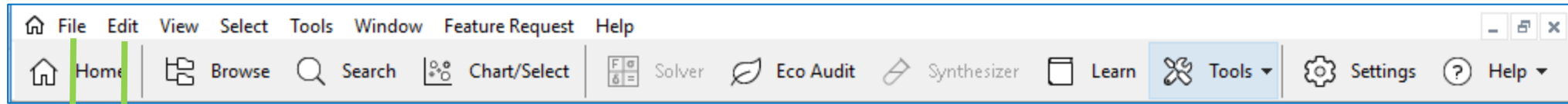
# Annotation tools in charts



# Changing the Chart settings (labels etc.)



# Saving projects, report writing



Clip-board

To WORD

For best results  
Paste Special -  
Device Independent Bitmap.

## Paste

**Acrylonitrile butadiene styrene (ABS)**

Description  
Image

Caption  
1. ABS pellets. © Shutterstock 2. ABS allows detailed moldings, accepts color well, and is tough enough to survive the worst that children can do to it. © Gettyimages

The material  
ABS (Acrylonitrile-butadiene-styrene) is tough, resilient, and easily molded. It is usually opaque although some grades can now be transparent, and it can be given vivid colors. ABS-PVC tougher than standard ABS and, in self-extinguishing grades, are used for the casings of power tools.

Compositional summary  
Block terpolymer of acrylonitrile (15-35%), butadiene (5-30%), and styrene (40-60%).

General properties

Density	1.01e3	-	1.21e3
Price	2.5	-	3
Date first used	1937	-	

Mechanical properties

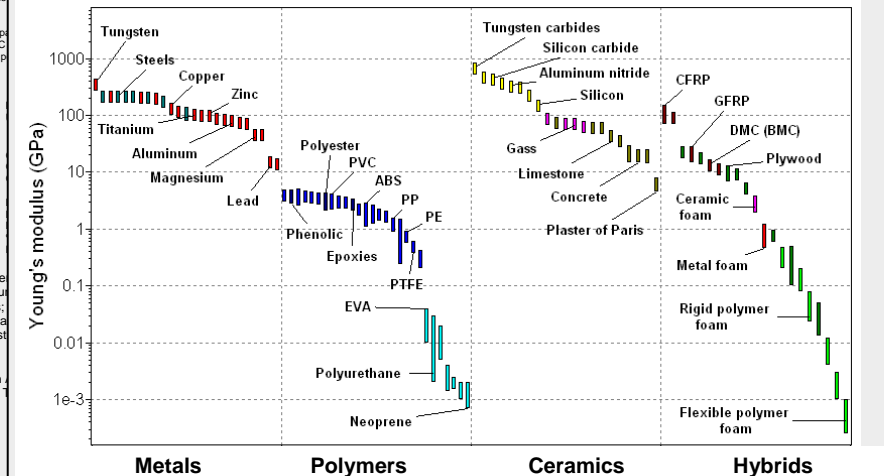
Young's modulus	1.1	-	2.9
Shear modulus	0.319	-	1.03
Bulk modulus	3.8	-	4
Poisson's ratio	0.391	-	0.422
Yield strength (elastic limit)	18.5	-	51
Tensile strength	27.6	-	55.2
Compressive strength	31	-	86.2
Elongation	1.5	-	100
Hardness - Vickers	5.6	-	15.3

Typical uses  
Safety helmets; camper tops; automotive instrument panels and other interior fittings; home-security devices and housings for small appliances; commercial business machines; plumbing hardware; automobile grilles; wheel covers; refrigerator liners; luggage shells; tote trays; mower shrouds; boat hulls; lawnmower recreational vehicles; weather seals; glass beading; refrigerator breaker switch waste-vent (DWV) systems.

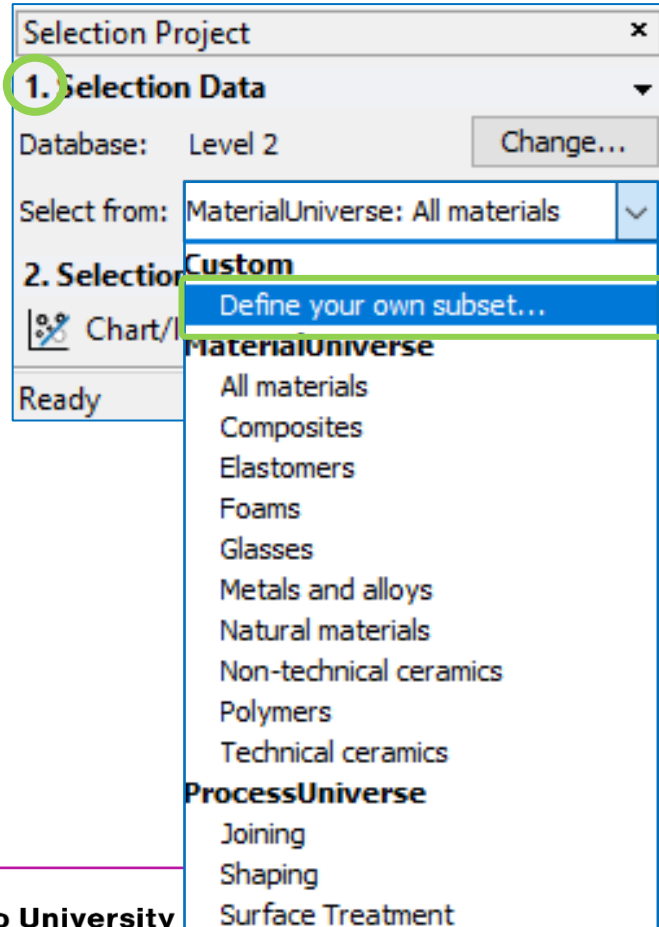
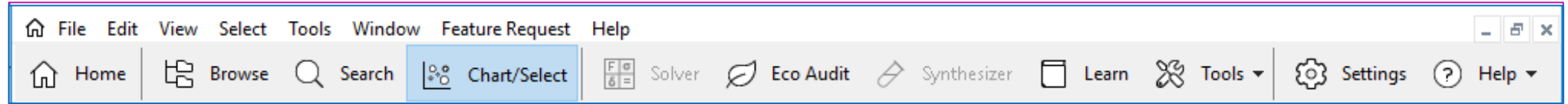
Tradenames  
Clardex, Comalloy, Cycogel, Cycolac, Hanalac, Lastilac, Lupos, Lustran, Novodur, Polyfabs, Polyfac, Porene, Ronfalin, Sinkral, Terluran, Toyolac, etc.

Links  
Reference  
ProcessUniverse  
Producers

## Copy - Paste



# Custom subsets



## Custom subset

**Selection table:**

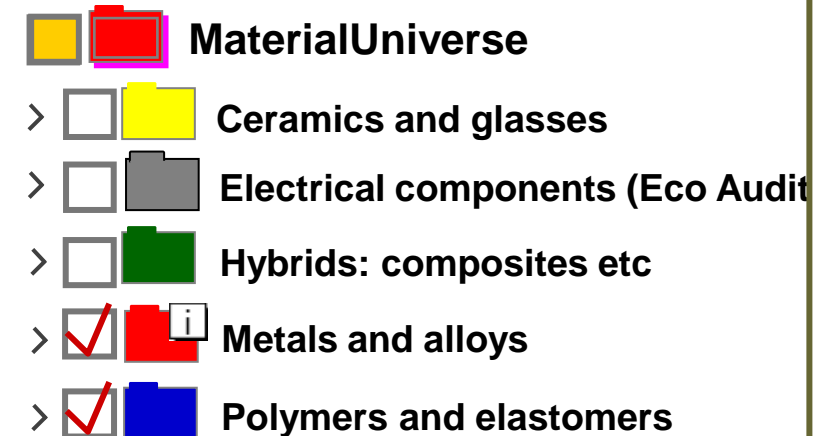
MaterialUniverse

**Initial subset:**

All materials

**Selection attributes:**

All properties





# Making your own records

The screenshot shows the GE software interface with the 'Tools' menu open. The 'Add Record' option is highlighted, and a green arrow points to the 'Add Record' dialog box. The dialog box contains the following fields and sections:

- Name:** My material
- Notes:** (empty text box)
- General properties** (expandable section)
- Mechanical properties** (expandable section with Min. and Max. columns):
  - Young's modulus: 230 (Min), 280 (Max) GPa
  - Yield strength: 1000 (Min), 1200 (Max) MPa
  - Hardness: (empty) (Min), (empty) (Max) Vickers
  - Fracture toughness: (empty) (Min), (empty) (Max) MPa.m<sup>1/2</sup>
- Thermal properties** (expandable section with Min. and Max. columns):
  - Max service temp: 30 (Min), 33 (Max) °C
  - T-conductivity: (empty) (Min), (empty) (Max) W/m.K
  - etc

On the right, a 'Table' dropdown menu is open, showing the following options: MaterialUniverse, MaterialUniverse, ProcessUniverse, Producers, and Reference. The 'MaterialUniverse' option is selected.

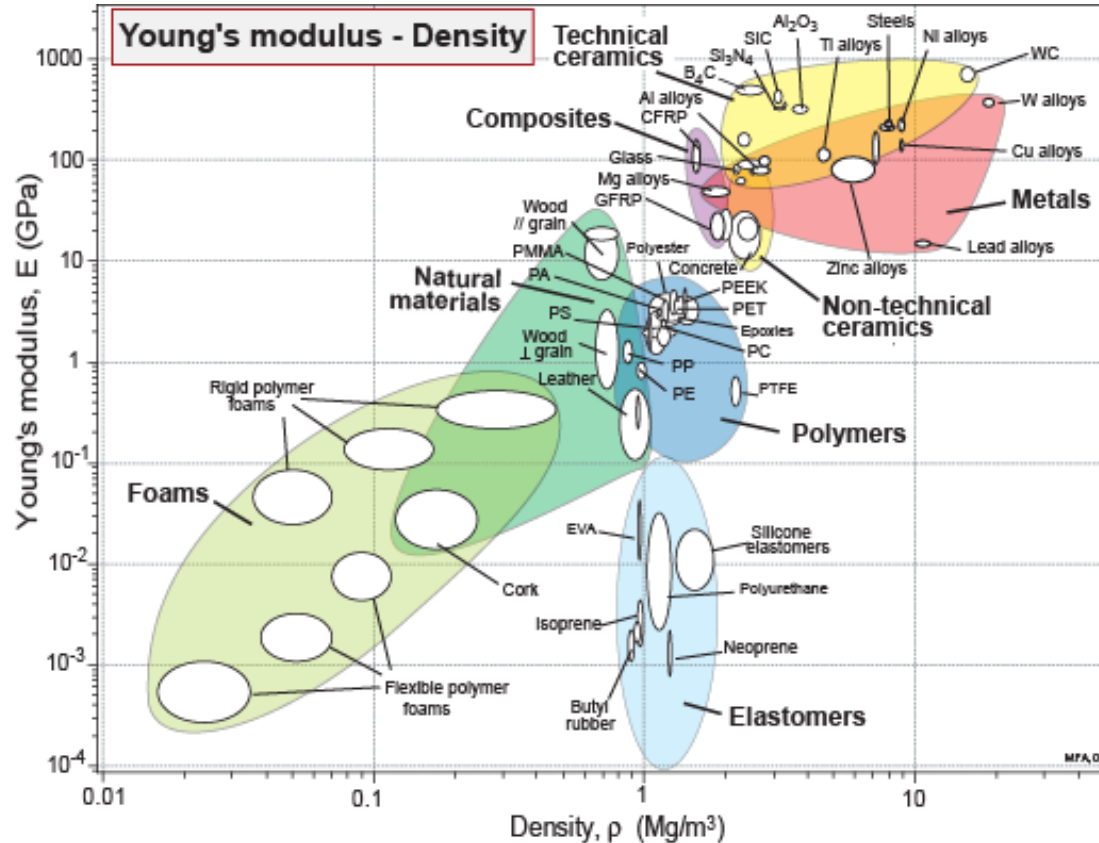
Below the main dialog box, there is a smaller window titled 'User Defined Record - MaterialUniverse'. It contains the following fields and sections:

- Record Details**:
  - Name:** (empty text box)
  - Color:** Orange (dropdown menu)
  - Notes:** (empty text box)
  - \* Records are not added to the database, but saved with the project file.**
- Selection Attributes**:
  - Density:** (empty text box) kg/m<sup>3</sup>
  - To add properties, include the attribute in your Selection Project first.**

The 'User Defined Record' window has 'OK' and 'Cancel' buttons at the bottom.

Or, right click on a chart to add limited data to it...

# Selection procedure



- Translation: deriving material index
- Screening: applying attribute limits
- Ranking: indices on chart
- Documentation

# Material index

Component performance is limited by either:

- one single material property e.g. **tensile strength**,  $\sigma_{ts}$
  - a group of material properties. **modulus / density**,  $E / \rho$
- material index**  
for the design*

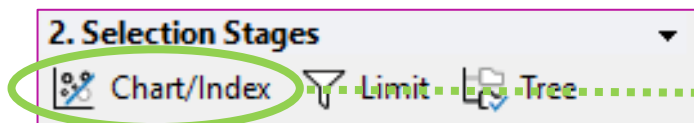
The screenshot shows the GRANTA EduPack software interface. The top menu bar includes File, Edit, View, Select, Tools, Window, Feature Request, and Help. Below the menu bar is a toolbar with icons for Home, Browse, Search, Chart/Select, Solver, Eco Audit, Synthesizer, Learn, Tools, Settings, and Help. The main window displays the 'Learn Online' section with a search bar and a grid of icons for Getting started, Introduction to material selection, Material selection (highlighted), Design projects, Reference, Download extras, and Throughout your career. To the right, a 'Table of performance indices' is shown, which is a table with columns for Mass, Cost, Embodied Energy, and CO2 Footprint, and rows for various design types.

	Mass	Cost	Embodied Energy	CO2 Footprint
Stiffness-limited design	kg	\$	$H_m$	CO <sub>2</sub>
Strength-limited design	kg	\$	$H_m$	CO <sub>2</sub>
Vibration-limited design				
Damage-tolerant design				
Abrasion-resistant design				
Thermo-mechanical design				
Electro-mechanical design				
Vapour barrier design				
Strength-limited design to optimize performance				

To maximize performance:

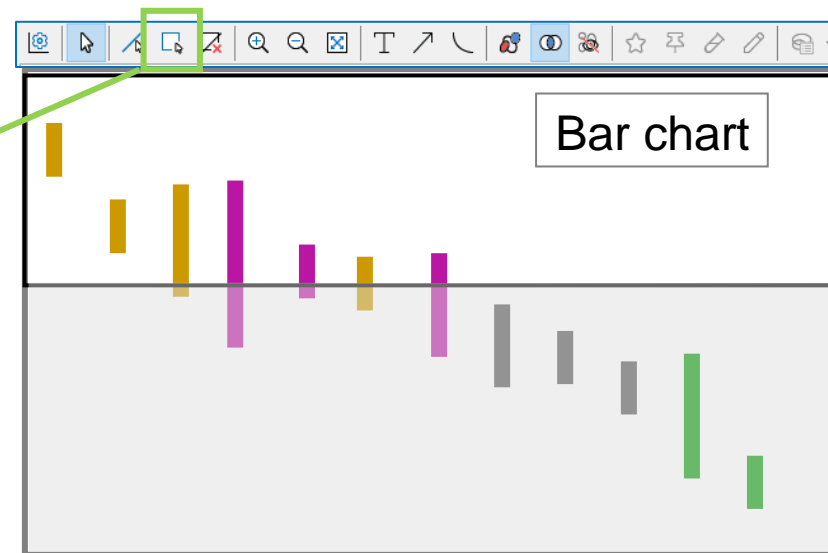
- First apply all **constraints**
- Then select materials with the **extreme index**

# Screening with a CHART STAGE



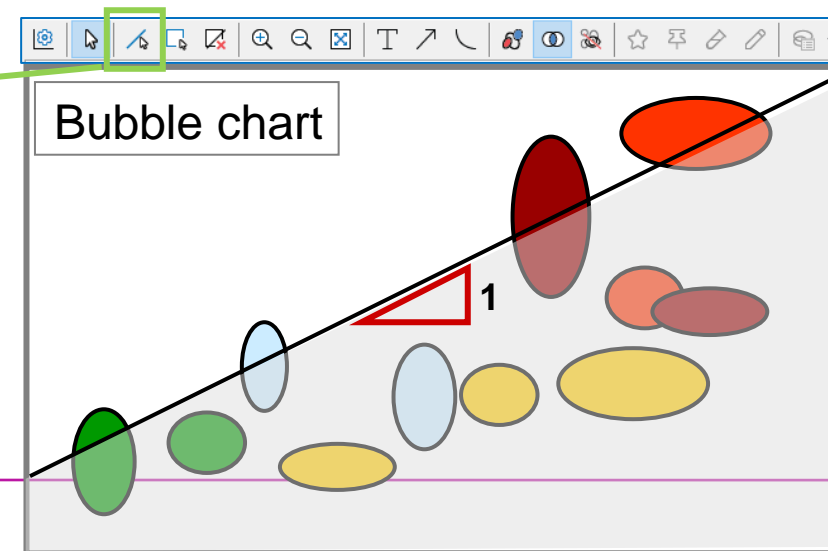
Box selection tool

Property



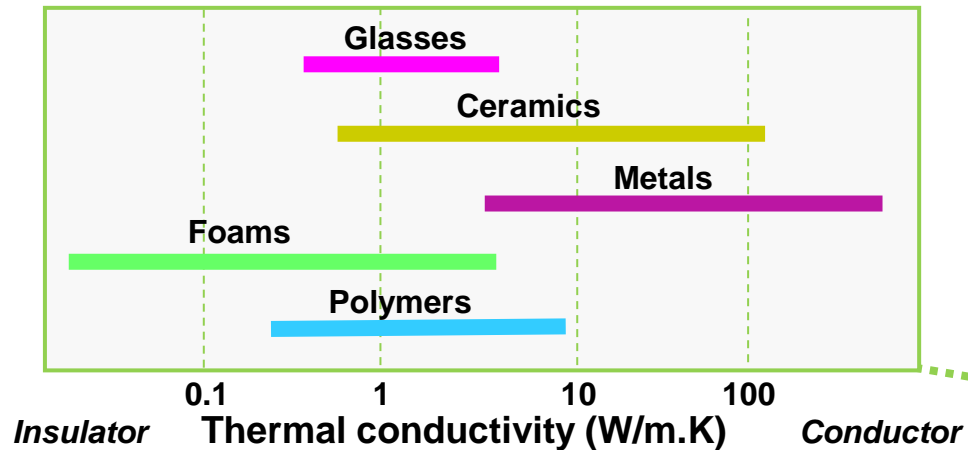
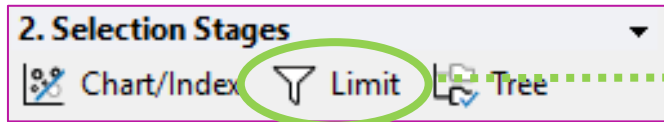
Line/gradient selection tool

Property 2



<b>Results</b>	<b>Ranking</b>	
<i>X out of 100 pass</i>	<i>Prop 1</i>	<i>Prop 2</i>
Material 1	2230	113
Material 2	2100	300
Material 3	1950	5.6
etc...		

# Screening with a LIMIT STAGE



Results <i>X out of 100 pass</i>	Ranking	
	Prop 1	Prop 2
Material 1	2230	113
Material 2	2100	300
Material 3	1950	5.6
etc...		

**General properties**

**Mechanical properties**    *Min.*    *Max.*

Young's modulus	<input type="text" value="100"/>	<input type="text"/>	GPa
Yield strength	<input type="text" value="50"/>	<input type="text"/>	MPa
Hardness	<input type="text" value="70"/>	<input type="text"/>	Vickers
Fracture toughness	<input type="text" value="16"/>	<input type="text"/>	MPa.m <sup>1/2</sup>

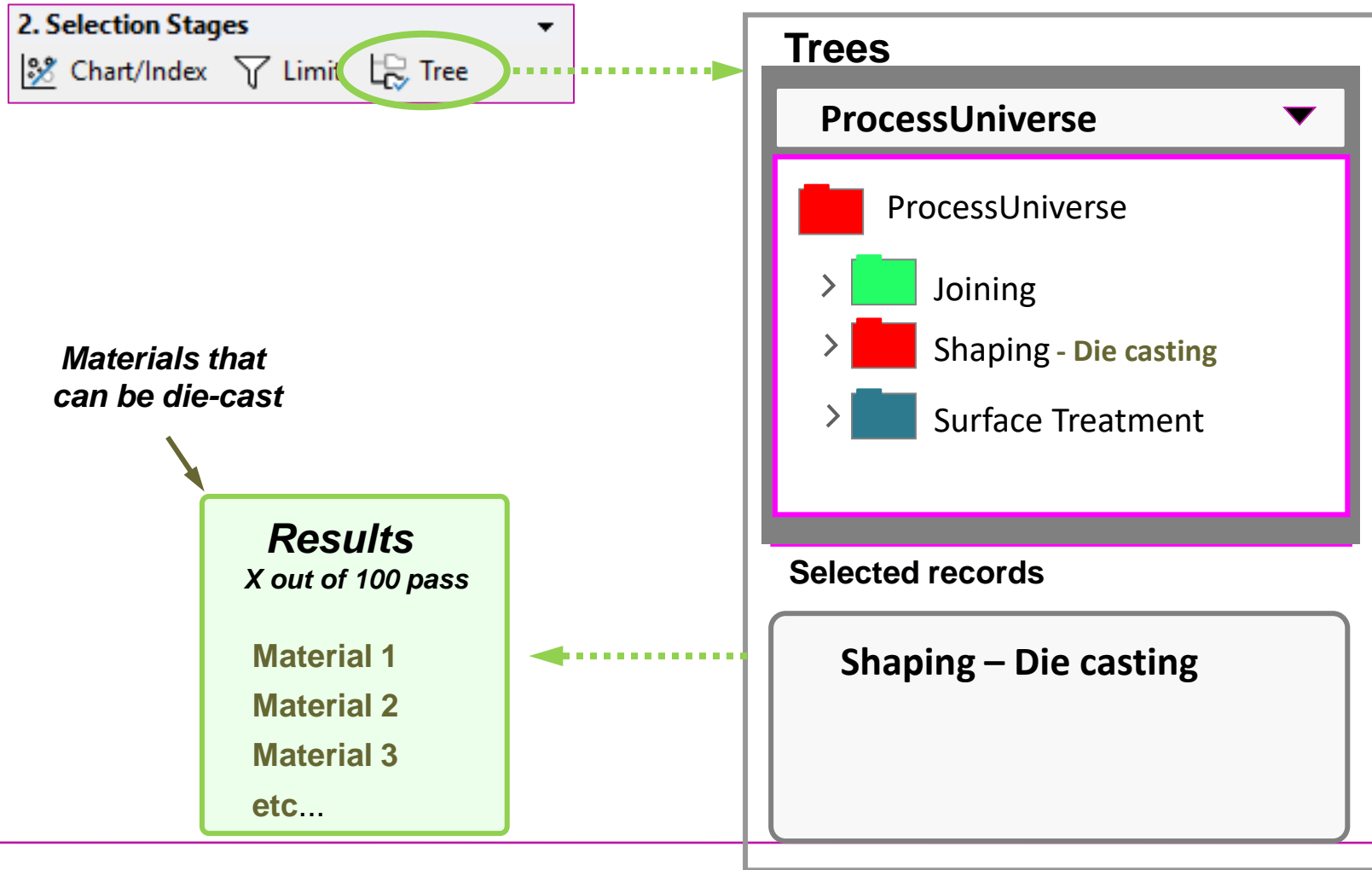
**Thermal properties**    *Min.*    *Max.*

Max service temp	<input type="text" value="200"/>	<input type="text"/>	C
T-conductivity	<input type="text"/>	<input type="text" value="1"/>	W/m.K
T-expansion	<input type="text"/>	<input type="text" value="10"/>	10 <sup>-6</sup> /C
Specific heat	<input type="text" value="1600"/>	<input type="text"/>	J/kg.K

**Electrical properties**

**Eco properties**

# Screening with a TREE STAGE



# Ranking, using charts

Light stiff beam:

Index  $M = \frac{E^{1/2}}{\rho}$

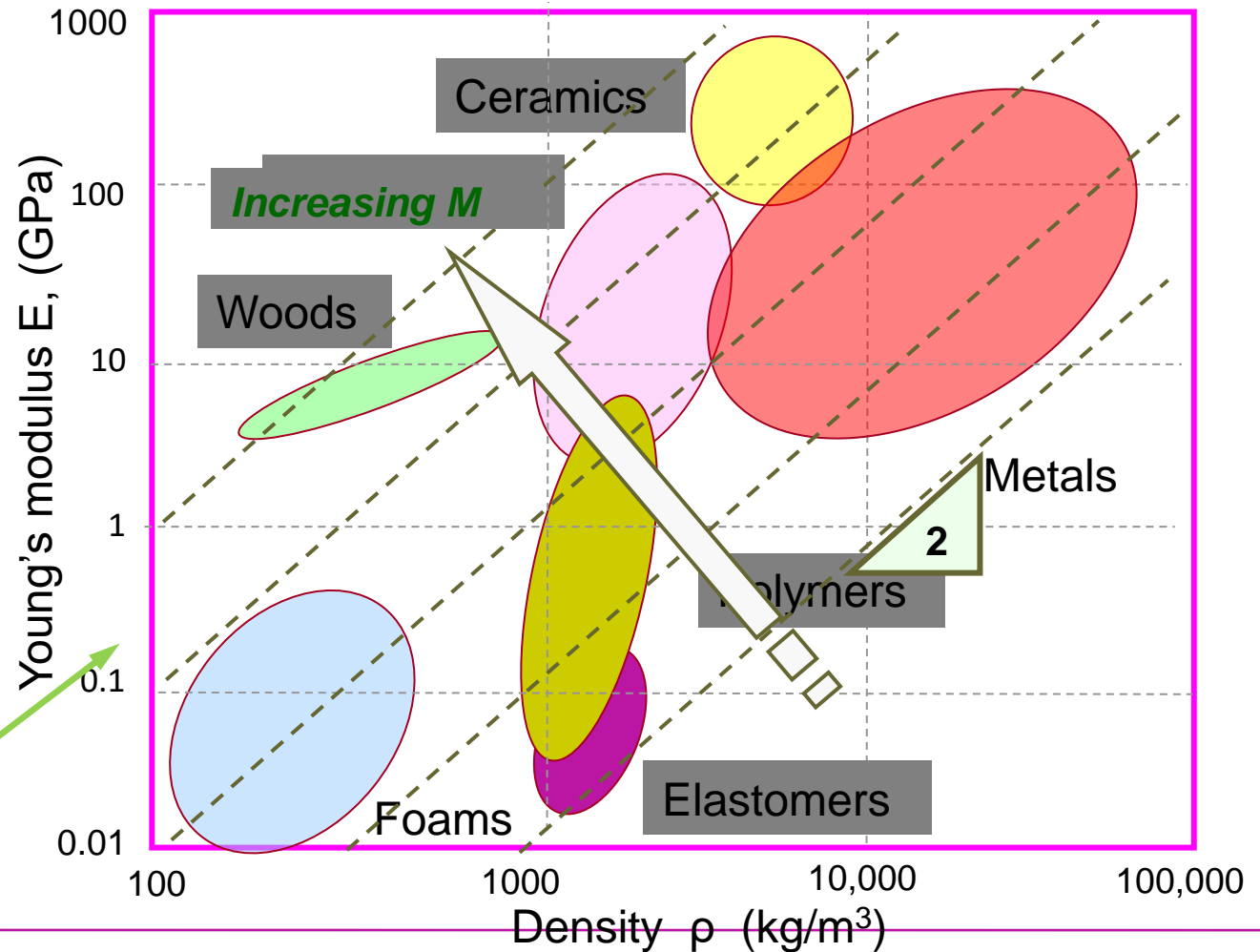
Rearrange:

$$E = \rho^2 M^2$$

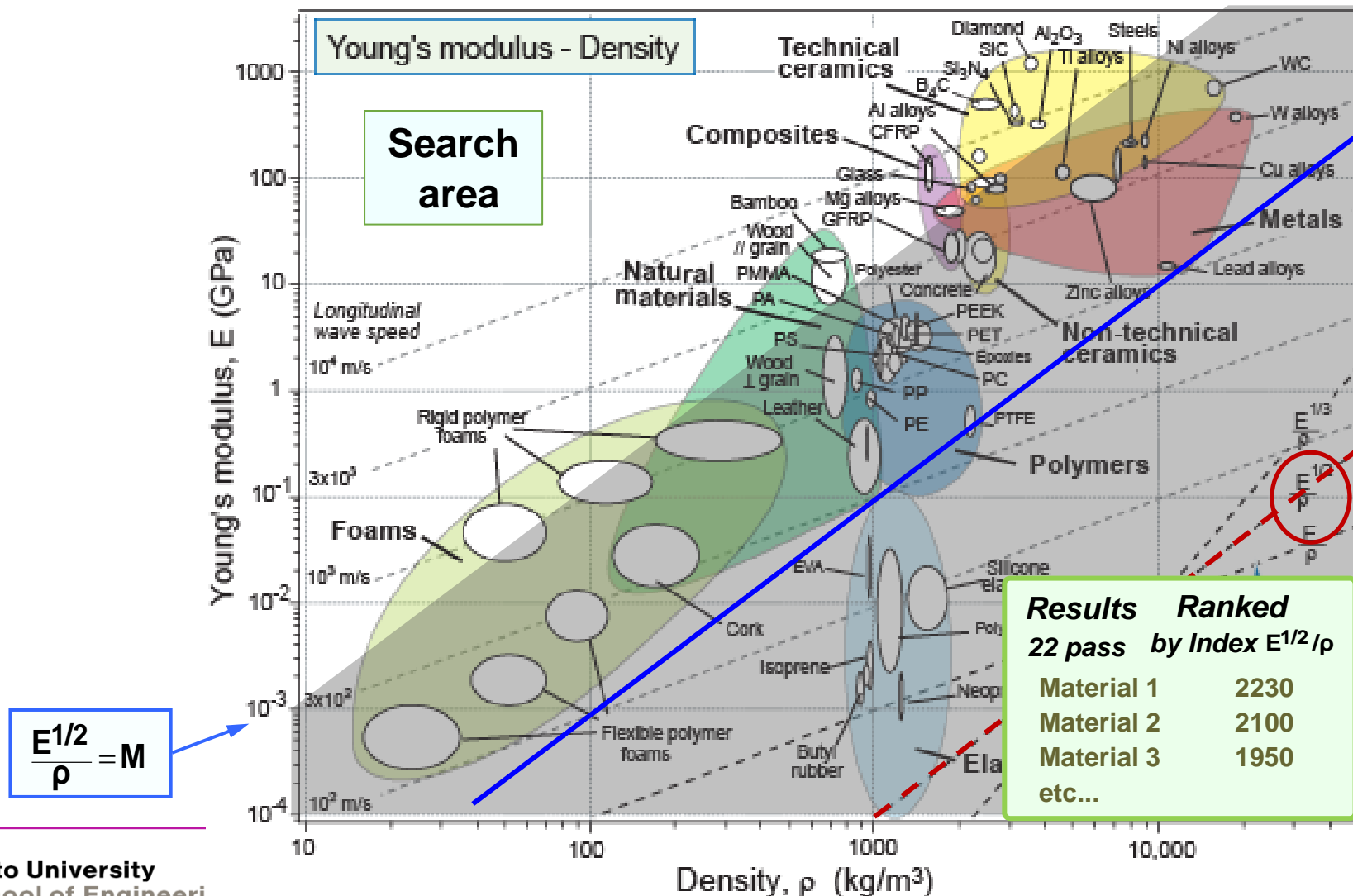
Take logs:

$$\log E = 2 \log \rho + 2 \log M$$

Function	Index	Slope
Tie	$E/\rho$	1
Beam	$E^{1/2}/\rho$	2
Panel	$E^{1/3}/\rho$	3

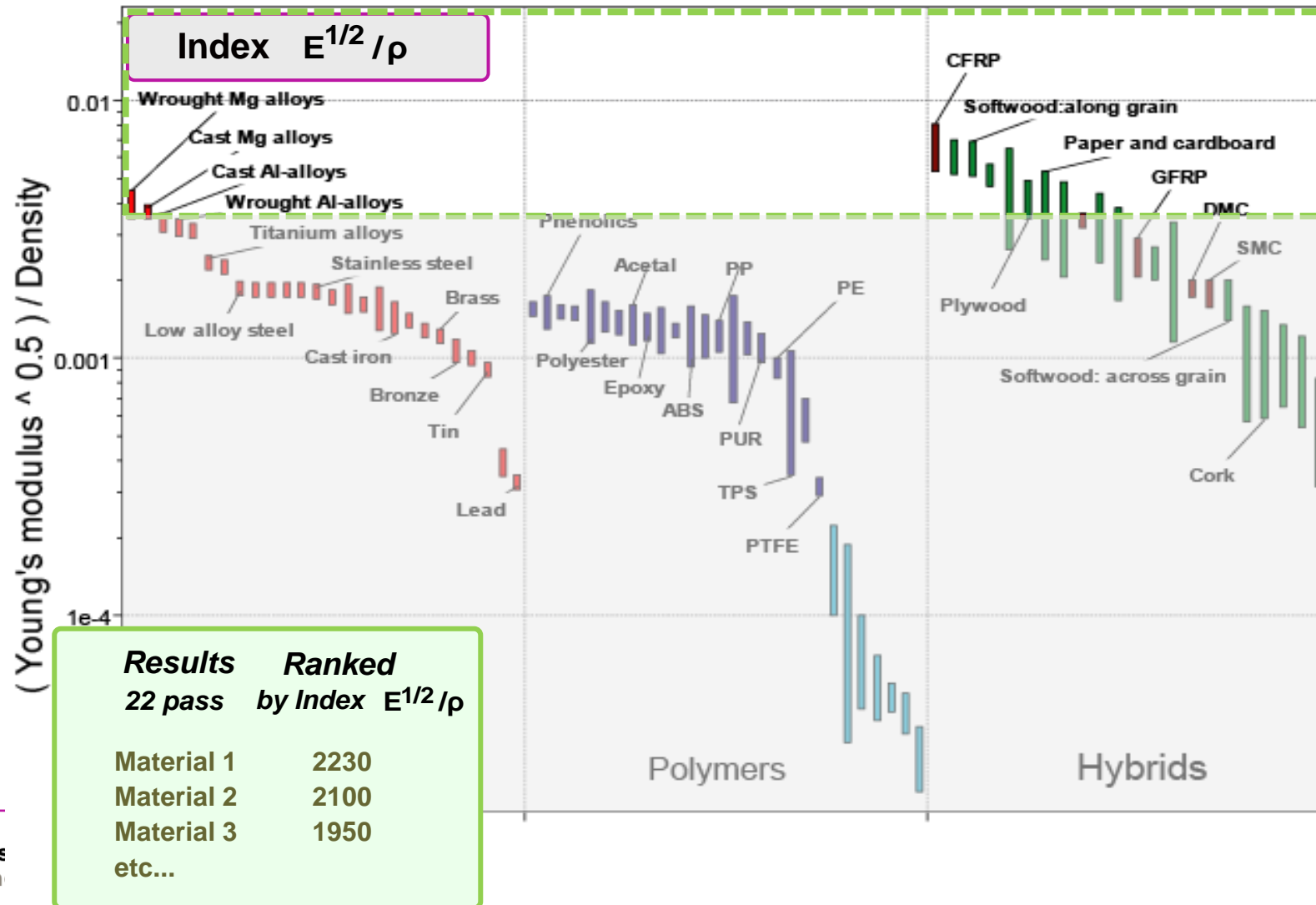


# Selection using index in a bubble chart





# Selection using index directly on chart axis



# Task 1

**Task 1.1:** Read the case study 6.2 “Materials for Oars” from the textbook.

Now follow the same method to choose one material from the material group listed below for a wind turbine blade. In the simplest case, the blade is a beam in bending. It should be as light as possible and have a given bending stiffness.

- First, define the **design requirements** in a table, including functions, constraints, objectives, and free variables, etc.
- Secondly, derive the formula for the material performance index from the performance objective. Note that the **derivation** (step-by-step) of the material performance index **must** be included in your report.
- Then draw the **maps** with level 2 and explain what the correct material **selection lines** are for this task.

*Hint:* Draw the Material Selection Maps on level 2 with density and Young’s modulus as axes.

Composites	Plastics
Foams	Non-technical ceramics
Metals	Technical ceramics
Elastomers	Natural materials

*Selection basics*

**Task 1.2:** Draw the maps from Task 1.1 on level 3. What differences do you notice? Give a detailed description based on your observation.

# Summary

- **Material property charts** gives meaning to data
- You can **visualize** any database, and **add your own records**

