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FOR INNOVATION THROUGH ENGINEERING SCIENCE


**V4 Seminars for Young Scientists on Publishing Techniques
in the Field of Engineering Science**

Presenting scientific results
- images and plots

Oliver Krammer
Budapest University of Technology and Economics



Contents




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- General requirements for presenting results (introduction)
- Image formats – vector graphics /bitmap based figures;
- Image editing techniques for bitmap images
- Plots, graphs and illustrations
 - Software tools for creating plots
 - Plot types
- Editing vector graphics
 - Illustrations
 - Posters

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2/73



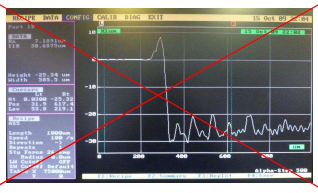
Illustrating scientific results



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„A PICTURE is said to be worth a thousand words“

- Clearly describes the results
- But the main aim is to capture the attention of readers
- Proves the high standard of the researcher's work
(helps in the reviewing process of scientific papers)




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3/73

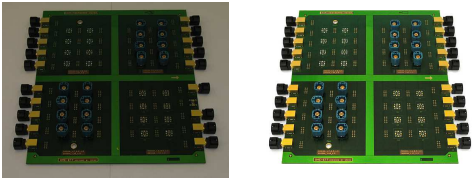
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First steps



General requirements about images, plots:

- **Always** read the „Guide for authors“ or the „Instructions for Authors“ for the „Artwork and media instructions“
- Contrast and white balance of photos, images should be properly adjusted




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4/73

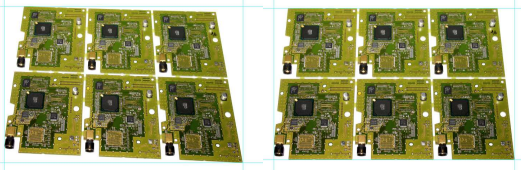
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General requirements



Photos taken about e.g. test sets, measurement sets etc.

- Try to compensate decently perspective projection distortion
- The same applies to any other linear and non-linear image distortions; and rotational offsets




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5/73

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General requirements



Lettering in images, plots:

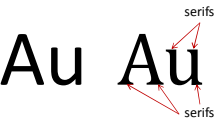
- It is best to use Arial, Calibri or Helvetica (sans-serif fonts) typefaces; the same applies to PowerPoint presentations
- Keep lettering consistently sized throughout the final-sized artwork, usually about 2–3 mm (8–12 pt) – **texts should be legible**

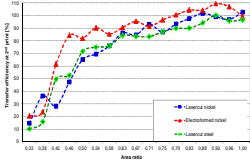
Sans-serif fonts

Arial, Calibri, Futura etc.

Serif (Roman) fonts

Times New Roman, Cambria, etc.





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6/73

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General requirements

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Lettering in images, plots:

- It is best to use Arial, Calibri or Helvetica (sans-serif fonts) typefaces; the same applies to PowerPoint presentations
- Keep lettering consistently sized throughout the final-sized artwork, usually about 2–3 mm (8–12 pt) – **texts should be legible**

Sans-serif fonts
Arial, Calibri, Futura etc.

Serif (Roman) fonts
Times New Roman, Cambria, etc.

Au Au

serifs

Area ratio	Laser-cut nickel	Electroformed nickel	Laser-cut steel
0.33	10	10	10
0.42	20	20	20
0.50	40	40	40
0.58	60	60	60
0.67	80	80	80
0.75	90	90	90
0.83	95	95	95
0.92	98	98	98
1.00	100	100	100

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7/73

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General requirements

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Lettering in images, plots:

- Variance of type size within an illustration should be minimal (can be 0), e.g., do not use 8-pt type on an axis and 20-pt type for the axis label
- Avoid effects such as shading, outline letters, etc.
- Do not include titles or captions within the illustrations of plots

Above liquidus

Reflow profile

Above liquidus

Reflow profile

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8/73

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Contents

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Image formats – vector graphics / bitmap based figures


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9/73

3


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Image formats – bitmap images



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- In computer graphics, when the domain is a rectangle (indexed by two coordinates) a **bitmap** gives a way to store a binary image, that is, an image in which each pixel is either black or white (or any two colours)
- The more general term **pixmap** refers to a map of pixels, where each one may store more than two colours, thus using more than one bit per pixel; often the term of **bitmap** is used for this as well.



Enlarged 12x to show individual pixels

Colour spaces:
RGB – red | green | blue
Grayscale (usually 255 shades)
CMYK – cyan | magenta | yellow | black
CIE lab, etc.

Bit depths:
8, 16, 32 bits / channel


*Sample raster graphic from FDT's collection of [color illustrations](#) on the [TIM website](#)

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10/73

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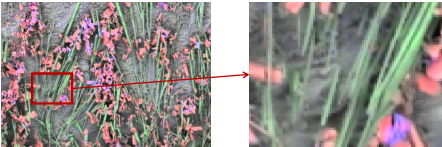
Image formats – bitmap images



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Properties of bitmap (raster) images

- Not scalable – resolution (measured usually in DPI – dot per inch) issues
- Can be edited by erasing or changing the colour of individual pixels (not one by one ☹)
- Preferred resolution for RGB images is usually 300 DPI, 300–600 DPI for grayscale images (e.g. SEM micrographs), 600–1200 DPI for line arts.




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11/73

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Bitmap images – file formats




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- TIFF or TIF – **Tagged Image File Format**: offers the option of using **LZW compression**, a lossless data-compression technique for reducing a file's size – this format is preferred in journal manuscripts
- PNG – **Portable Network Graphics**: also supports lossless data compression; PNG is upcoming but not being supported by the most of the journal publishers; can be opted for conference papers
- JPG – **Joint Photographic Experts Group**: provides the smallest file size, but uses lossy compression method; use with care in conference papers

png

jpg - l

jpg - s



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12/73

4

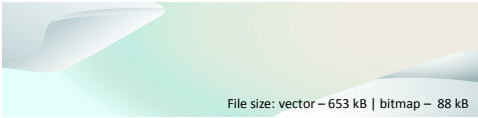
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Vector graphics - disadvantages

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Vector formats are not always appropriate in graphics work and also have numerous disadvantages

- Devices such as cameras and scanners produce essentially continuous-tone raster graphics that are impractical to convert into vectors
- Vector graphic with a small file size is often said to lack detail compared with a real world photo
- Colour gradients can consists of many primitive objects – large file sizes



File size: vector – 653 kB | bitmap – 88 kB

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16/73

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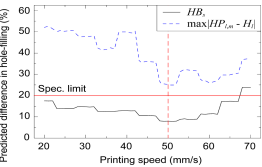
Vector graphics – file size

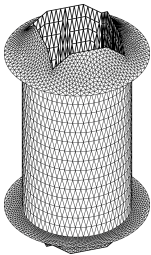
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Always check that the file size does not exceed ~1 MB

Vector graphics with many objects (e.g. plots with many data points) can really be large

Bitmap (600 DPI): 370 kB
Vector graphic: 175 kB





Bitmap (600 DPI): 270 kB
Vector graphic: 3.2 MB

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17/73

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Image editing techniques for bitmap images

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18/73

6

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Image manipulation

General policy about manipulating images

„...no specific feature within an image may be enhanced, obscured, moved, removed, or introduced. Adjustments of brightness, contrast, or color balance are acceptable if and as long as they do not obscure or eliminate any information present in the original. Manipulating images for improved clarity is accepted, but manipulation for other purposes could be seen as scientific ethical abuse...”

(Rossner and Yamada, 2004. The Journal of Cell Biology, 166, 11-15.
<http://jcb.rupress.org/content/166/1/11.full>)

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19/73

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Photo editors

Free photo editors:

- **GIMP** (the GNU Image Manipulation Program) is the most powerful free photo editor; it's packed with the kind of image-enhancing tools you'd find in premium software
- **Paint.NET**'s simplicity is one of its main selling points; it's a quick, easy to operate free photo editor

Commercial photo editors:

- **Adobe Photoshop** was created in 1988; since then, it has become the de facto industry standard in raster graphics editing
- **Corel Photo-Paint** is a raster graphics editor developed and marketed by Corel since 1992; it is the primary market competitor of Adobe Photoshop



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20/73

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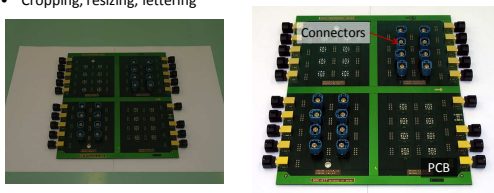
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Adjusting bitmap images

Bitmap images usually need some adjustment before inserting them into scientific papers:

- Adjusting parameters of brightness, contrast via „Levels“, and white balance; adjusting image distortions
- Cropping, resizing, lettering




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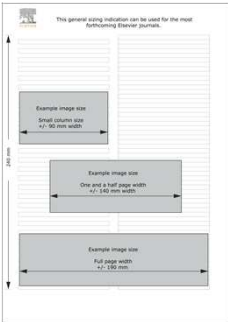
21/73

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Artwork sizing



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This general sizing indication can be used for the image accompanying Elsevier journals.

- Read the „Guide for authors” about the recommended sizing
- Use mainly the „small column size”:
 - 90 mm @ Elsevier
 - 84 mm @ Springer etc.
- Recommended:
 - width is 80 mm
 - height is 50–60 mm


Target size, col.	Width (mm)	Pixels 300 DPI	Pixels 600 DPI	Pixels 1200 DPI
Min.	30	354	709	1417
Single	90	1063	2126	4252
1.5 col.	140	1654	3307	6614
Double	190	2244	4488	8976

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31/73

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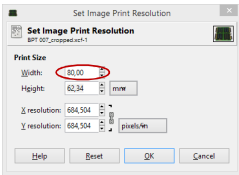
Setting print size



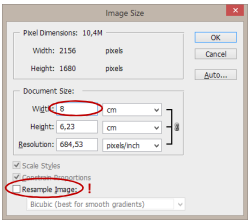
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- Set the width of print size to ~80 mm
- Pay particular attention to the pixel count, it should remain the same

GIMP



Photoshop




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32/73

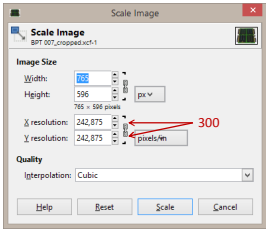
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Checking resolution



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- If the resolution is higher than the mentioned -> OK
 - Colour RGB – 300 DPI; grayscale – 300–600 DPI; line art – 600–1200 DPI
- If it is lower -> resize, scale – see the editor manual for interpolations



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33/73

11

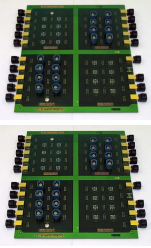
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Image sharpening

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• If resizing, scaling was necessary try a slight „Unsharp mask“

• Use very low values for the parameters; radius, amount: ~1–1.2, threshold: 3



Unsharp Mask

Preview

Radius

1.0

Amount

1.00

Threshold

3

Help

OK

Cancel

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34/73

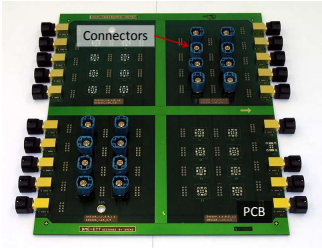
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Texts, lettering

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• Use font size of ~10 pt. Verify that the unit for text size is „pt“; not „px“

• Use transparent boxes for text background, if the image is very detailed



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35/73

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Enhancing low resolution images

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• Can be enhanced visually, if the letterings are rewritten in high resolution



13-month running centered average

Median after 1998 El Niño

Median prior to 1998 El Niño

13-month running centered average

Median after 1998 El Niño

Median prior to 1998 El Niño


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36/73

12

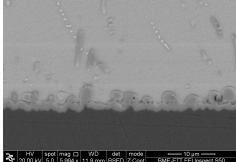
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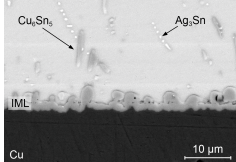
Microscopy images, micrographs



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- Microscope-generated scale bars should be replaced by larger, more legible scale bars
- Magnifications should not be given (e.g., 1000×) in images
- The contrast should be adjusted to fill the grey levels so long as it does lead to misinterpretation of the visual information being presented






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37/73

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Contents



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Plots, graphs and illustrations

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38/73

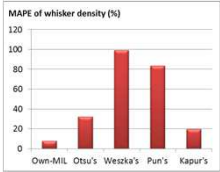
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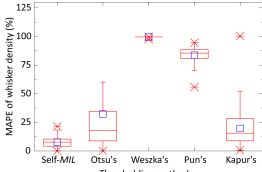
First steps



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- Excel is not recommended for producing plots for scientific publications
- There are many free tools – mostly command-line driven utilities; the learning curve can be steep
- Commercial tools are usually more user friendly; license availability should be checked at the institute









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39/73

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Free tools for producing plots





- **R** is a programming language and free software environment for statistical computing and graphics that is supported by the R Foundation for Statistical Computing; optionally using **Rstudio** and **ggplot2** plotting system
- **gnuplot** is a portable, multi-platform, command-line driven graphing utility; features include 2D and 3D plotting, a huge number of output formats, interactive input or script-driven options, and a large set of scripted examples
- **Python** with **matplotlib**; Matplotlib can be used in Python scripts, the Python and IPython shells, the Jupyter notebook, web application servers, and four graphical user interface toolkits

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40/73

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Commercial tools for producing plots


- **Matlab** – institutional license is usually available; customising plots can be difficult – many plot details require “try & error” since help is brief; but there are some nice tutorials
 - <https://dgleich.wordpress.com/2013/06/04/creating-high-quality-graphics-in-matlab-for-papers-and-presentations/>
 - <https://blogs.mathworks.com/loren/2007/12/11/making-pretty-graphs/>
- **Origin(Pro)** is a data analysis and graphing software, which offers an easy-to-use interface for beginners, combined with the ability to perform advanced customization
- **GraphPad Prism** was originally designed for experimental biologists in medical schools and drug companies, offers graphing and comprehensive curve fitting options
- ... and many more: **SPSS**; **SigmaPlot**; **Stata**; **Statistica**; **EZL** etc.

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41/73

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Producing plots, graphs



When it comes to plotting, less is more

- Poorly constructed graphs can make data difficult to discern and thus interpret
- Avoid creating misleading graphs and plots
- Graphs and plots are designed to allow easier interpretation of statistical data; however, excessive complexity can obfuscate the data and make interpretation difficult

„Perfection is achieved not when there is nothing more to add, but when there is nothing left to take away.”

*Antoine de Saint-Exupery

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42/73

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Chartjunks

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- Omit „chartjunks” - all visual elements in plots, charts and graphs that are not necessary to comprehend the information represented on the graph; e.g. heavy grid lines, unnecessary text, inappropriately complex font faces, ornamented chart axes, pictures or icons within data graphs, shading etc.

The MIL over cooling rate

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43/73

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- Remove background and special effects as bevelling, shadowing etc.
- Reduce colours inside symbols, but use different colours and symbol types between data sets
- Remove redundant labels like title, captions
- Remove border

The MIL over cooling rate

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44/73

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Page size -> font face

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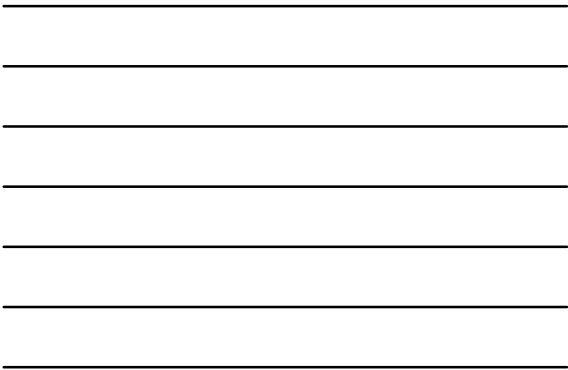
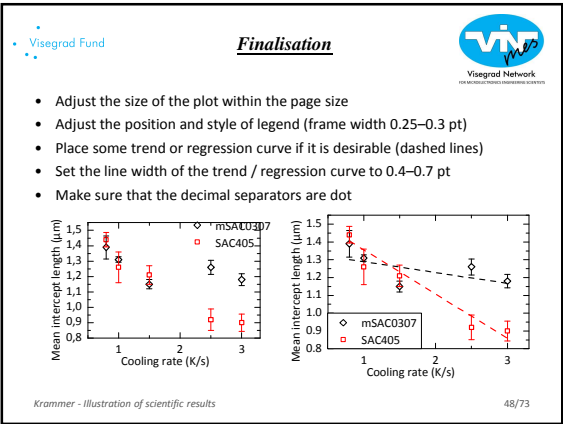
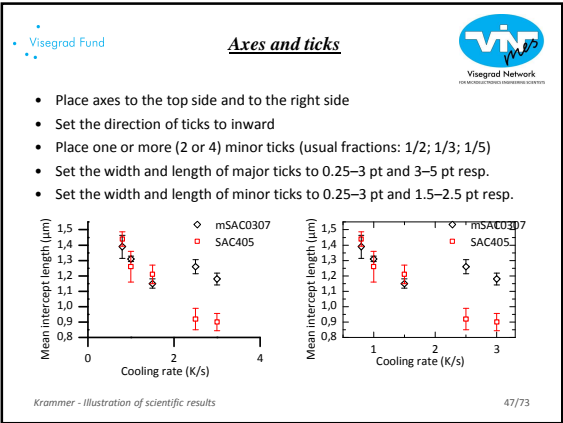
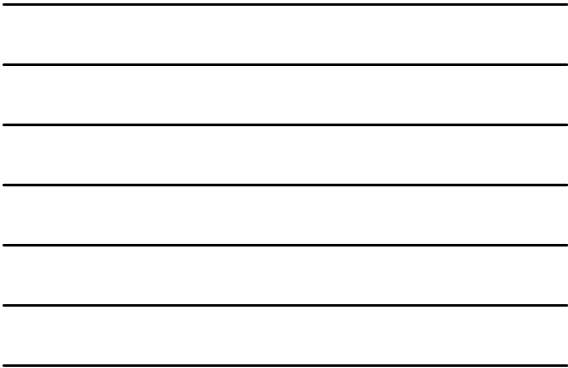
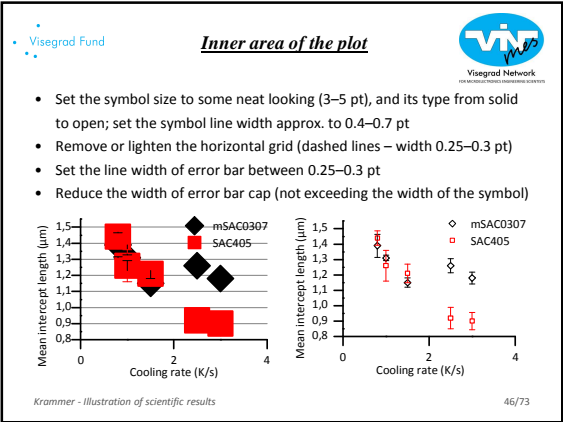
FOR RESEARCHER-DRIVEN SCIENTIFIC RESULTS

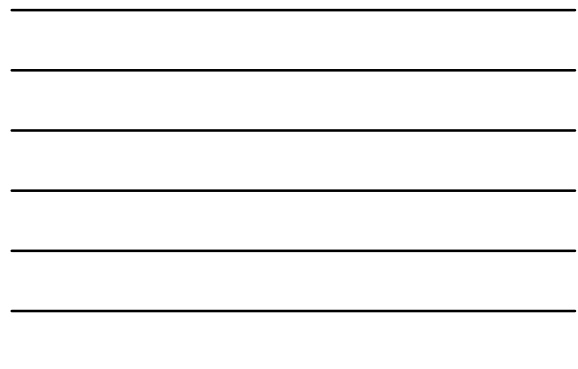
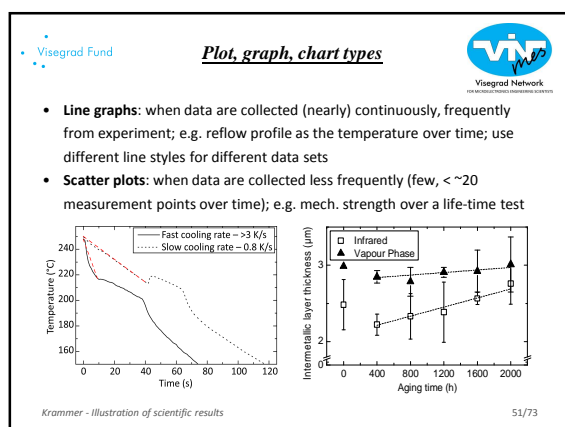
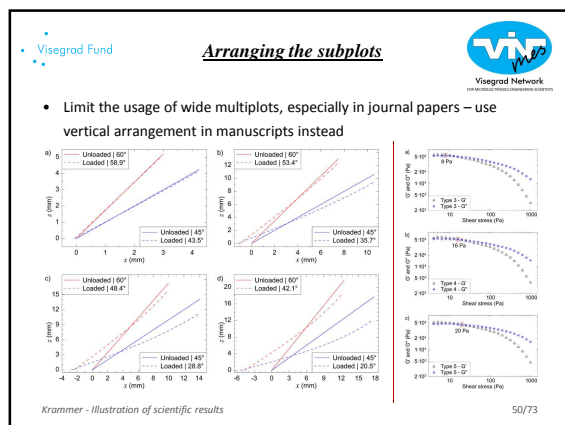
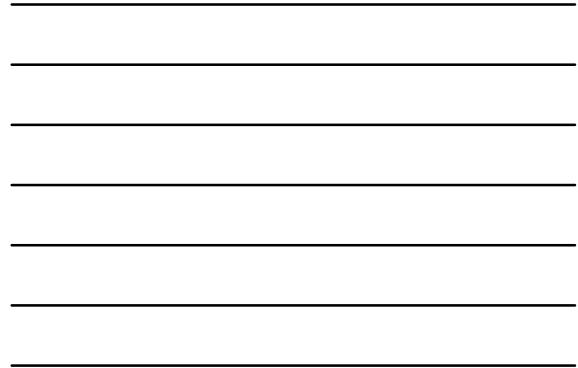
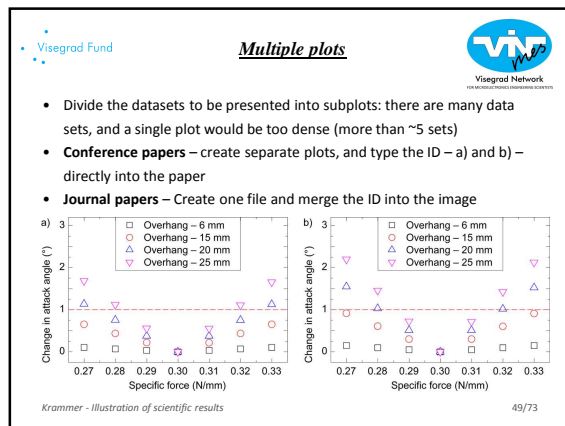
- Set the page size of the plot (~ 80 x 55 mm)
- Then the font size can be adjusted
- Use nearly the same font size for axis titles and labels (~ 9–10 pt)
- Remove bolding
- Move the legend into the inner area of the plot

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45/73

15





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Plot, graph, chart types

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- **Box plots:** when distinct sets of data (abscissa is qualitative not quantitative) are intended to be compared and/or the statistical properties of measured parameter is intended to be emphasized
- **Polar plots:** when a parameter has directional dependence, presented with radius r as a function of angle θ , e.g. antenna pattern

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52/73

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Special types of plots

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- **Histogram:** an accurate representation of the distribution of numerical data; it is an estimate of the probability distribution (density function) of a continuous variable (quantitative variable)
- To construct a histogram, the first step is to "bin" the range of values— that is, divide the entire range of values into a series of intervals
- Then count how many values fall into each interval (height of the bars)
- A histogram may also be normalized to display "relative" frequencies

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53/73

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Special types of plots

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- **Pareto chart:** the purpose of the Pareto chart is to highlight the most important among a (typically large) set of factors
- It is a type of chart that contains both bars and a line graph, where individual values are represented in descending order by bars, and the cumulative total is represented by the line
- The left vertical axis is the frequency of occurrence, but it can alternatively represent cost or another important unit of measure

<https://commons.wikimedia.org/wiki/File:Pareto.PNG>

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54/73

18

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Special types of plots

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- **P-P plot:** is a probability plot for assessing how closely two data sets agree, which plots the two cumulative distribution functions against each other
- The **Q-Q plot** is more widely used, but they are both referred to as "the" probability plot, and are potentially confused

https://commons.wikimedia.org/wiki/File:Probability-Probability_plot_quality_characteristic_data.png

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55/73

- **Q-Q plot:** is a probability plot, which is a graphical method for comparing two probability distributions by plotting their quantiles against each other
- If the two distributions being compared are similar, the points in the Q-Q plot will approximately lie on the line $y = x$
- The **normal probability plot** is a special case of the Q-Q plot for testing a parameter to normal distribution

<https://commons.wikimedia.org/wiki/File:Normprob.png>

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56/73

- **Weibull plot:** has special scales that are designed so that if the data follow a Weibull distribution, the points will be linear (or nearly linear)
- The shape parameter is the reciprocal of the slope of the fitted line
- The scale parameter is the exponent of the intercept of the fitted line, or the value of abscissa, where the parameter is 63.2

The figure is a Weibull plot. The x-axis is labeled 'Sample Data' and has a logarithmic scale with major ticks at 20, 40, 60, 80, and 100. The y-axis is labeled 'Weibull Percentiles' and has a 'Double Log Reciprocal' scale with major ticks at 1, 5, 10, 50, 90, 99, and 99.9. A legend in the top left corner identifies the plot elements: blue circles for 'Percentiles', a solid red line for 'Reference Line', a light red shaded area for 'Lower Percentiles', and a light pink shaded area for 'Upper Percentiles'. The data points (blue circles) are plotted along the reference line, showing a strong linear trend on this probability-log scale. The shaded regions represent the confidence intervals around the fitted line.

[https://www.originlab.com/doc/en/Tutorial/Images/Weibull_Probability_Plot_8.png](https://www.originlab.com/doc/en/Tutorial/Images/Weibull_Probability_Plot/Graph_Gallery_Weibull_Probability_Plot_8.png)
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57/73

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Special types of plots

VIN

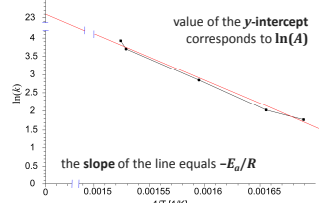
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• **Arrhenius plot:** displays the logarithm of a reaction rate constant, $\ln(k)$ plotted against inverse temperature

• Often used to analyse the effect of temperature on the rates of chemical reactions

$x(t,T) = x_0 + t^n \cdot k_0 \cdot e^{-E_a/RT}$
 $\rightarrow x(t,T) - x_0 = k$
 $\rightarrow t^n \cdot k_0 = A$
 $k = Ae^{-E_a/RT}$
 $\rightarrow \ln(k) = \ln(A) - \frac{E_a}{R} \left(\frac{1}{T} \right)$



value of the y-intercept corresponds to $\ln(A)$

the slope of the line equals $-E_a/R$

https://commons.wikimedia.org/wiki/User:Matthias_M_

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58/73

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Plot types

VIN


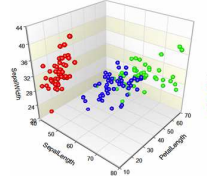
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• Try to avoid 3D plots – usually they can hardly be interpreted

• Bar charts (except special types – histogram, Pareto etc.) and pie charts should not be used to represent data in scientific papers

• Use box plots instead of bar charts – statistical properties of the data set are also presented by that



www.psdgraphics.com

https://commons.wikimedia.org/wiki/User:Matthias_M_

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59/73

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Contents

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Editing vector graphics – illustrations – posters

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Krammer - Illustration of scientific results

60/73

20

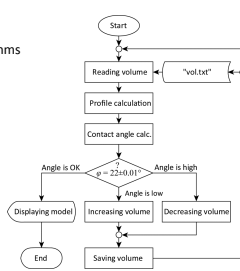
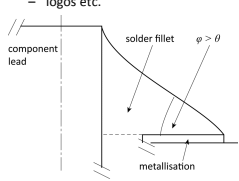
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Vector graphics - illustration

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- Plots can be post processed, if required by vector editing tools
- Line art illustrations:
 - technical drawings
 - block diagrams of processes, algorithms
 - functional flow diagrams
 - logos etc.



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61/73




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Free tools for vector graphics

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- Inkscape:** is a free and open-source vector graphics editor; it can be used to create or edit vector graphics such as illustrations, diagrams, line arts, charts, logos and complex paintings; Inkscape's primary vector graphics format is Scalable Vector Graphics (**SVG**), however many other formats can be imported and exported
- Vectr:** is a good basic editor you can use for almost any vector task; it doesn't have as many features as Inkscape, which makes it easier for beginners
- Dia:** is free and open source general-purpose diagramming software; it has a modular design with several shape packages available for different needs: flowchart, network diagrams, circuit diagrams, and more



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62/73




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Commercial tools for vector graphics

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- Adobe Illustrator:** is a vector graphics editor developed and marketed by Adobe Systems; companion product of Adobe Photoshop; provides results in the typesetting and logo graphic areas of design
- CorelDRAW:** is developed and marketed by Corel Corporation; it is also the name of Corel's Graphics Suite, which bundles CorelDraw with bitmap-image editor Corel Photo-Paint as well as other graphics-related programs
- Microsoft Visio:** is a diagramming and vector graphics application and is part of the Microsoft Office family – check institutional license; it provides detailed shapes for site plans and floor plans, IEEE compliant shapes for electrical etc.




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63/73

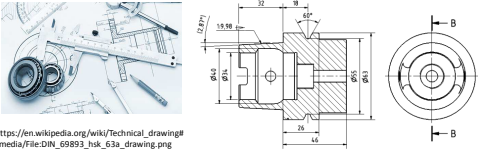
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Creating technical drawings, illustrations



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- Basic steps are very similar to the steps of creating plots
- Set the page size: width ~ 80 mm | height 50 – ~150 mm
- Use sans-serif font face and font size of ~9–10 pt
- Contours width: 0.4–0.7 pt (thinner than standard: 0.7 mm – 2 pt)
- Auxiliary lines: 0.25–0.3 pt (thinner than standard: 0.3 mm – 0.85 pt)
- Set a grid for technical drawings aiding the




https://en.wikipedia.org/wiki/Technical_drawing#/media/File:DIN_69893_hsk_63a_drawing.png

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64/73

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Vector graphics in final papers



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- Do **assure** at proofing stage that your vector graphic illustrations were not misused by the journal publisher – check the .pdf proof

Bitmap is used instead of vector

Vector is used

Figure 2 Calculating the length of volume

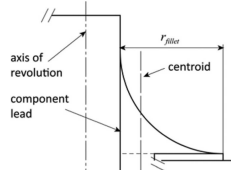
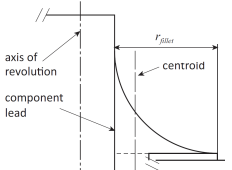


Figure 2 Calculating the length of volume




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65/73

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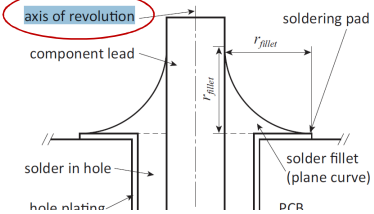
Vector graphics in final papers



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- The most correct: texts in vector graphics are selectable in the pdf proof

Figure 1 Model for solder fillet volume calculation




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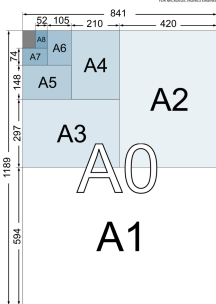
66/73

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Poster presentations


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- A poster requires you to distil the work, yet not lose the message or the logical flow
- Either a vector graphics editors or Microsoft PowerPoint (or OpenOffice) can be used by setting the appropriate page size
- Read the guide for authors of the conference (or forum)
 - Portrait or landscape?
 - A1 – 841 x 594 cm
 - A0 – 1189 x 841 cm




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67/73



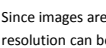

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Images in posters



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FOR EUROPEAN RESEARCH EXCELLENCE

- Use as many illustration in vector format as possible, logos, graphs etc.
- Limit the usage of bitmap images to photos about the experiment, and about the results which were taken by camera (optical micr., SEM etc.)
- Since images are larger in posters (can even be wider than 20 cm), the resolution can be reduced to about 200 DPI, but not lower – still, image lettering can be problematic (resetting lettering in ppt?)

Krammer - illustration of scientific results

68/73

- Visegrad Fund

Posters – texts and layouts

- Should be readable from about 1.5 – 2 m
- Should be clearly organised – consistent and clear layout
- Avoid too much text – word count of about 300 to 800 words (preferred up to 400 word) – distillation of work
- Avoid ALL-CAPS, as they are HARD TO READ

Krammer - illustration of scientific results

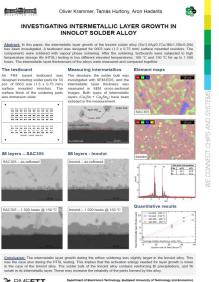
69/73

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Posters – texts and layouts

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- Organize and align your content with columns, sections, headings, and blocks of text
- Use sans-serif fonts
- Title: 72-120 pt
- Subtitle: 48-80 pt
- Section headers: 36-72 pt;
50 pt is recommended
- Body text: 24-48 pt;
40 pt is recommended
- Tables and image lettering:
~30 pt



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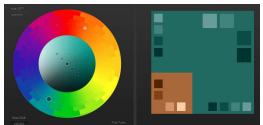
70/73

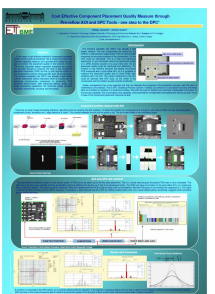
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Posters – colours

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- Choose colours carefully (2 or at most 3 colours)
- Pay attention to contrast
- Dark print (black or dark blue) on light background (white background) is best
- <http://paletton.com>





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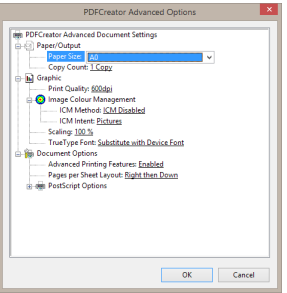
71/73

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Printing posters

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- Provide a .pdf file for the printing office, usually it is more stable
- Try virtual printers (pdf-printer), e.g. PDFCreator – better compatibility with EPS files
- Set the page size of „pdf-printer“ according to your poster size (A0, A1?)



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72/73

24


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Conclusions

- Do not afraid from vector graphics
- Learn all the tools, which are necessary for creating nice plots and illustrations
- Devote time to edit images, illustrations, plots, posters
- Analyse the plots and illustrations in cited papers from the design point of view



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73/73
