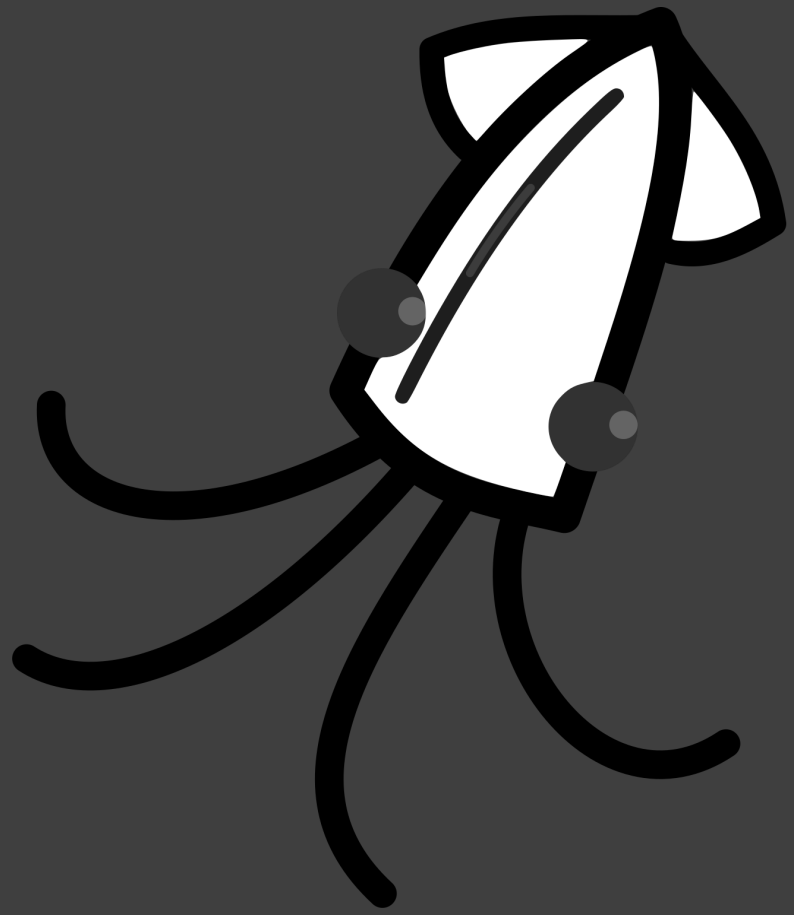
CALAMARI

Contrast Analyzer of Few
Layer Van-der-Waals Materials



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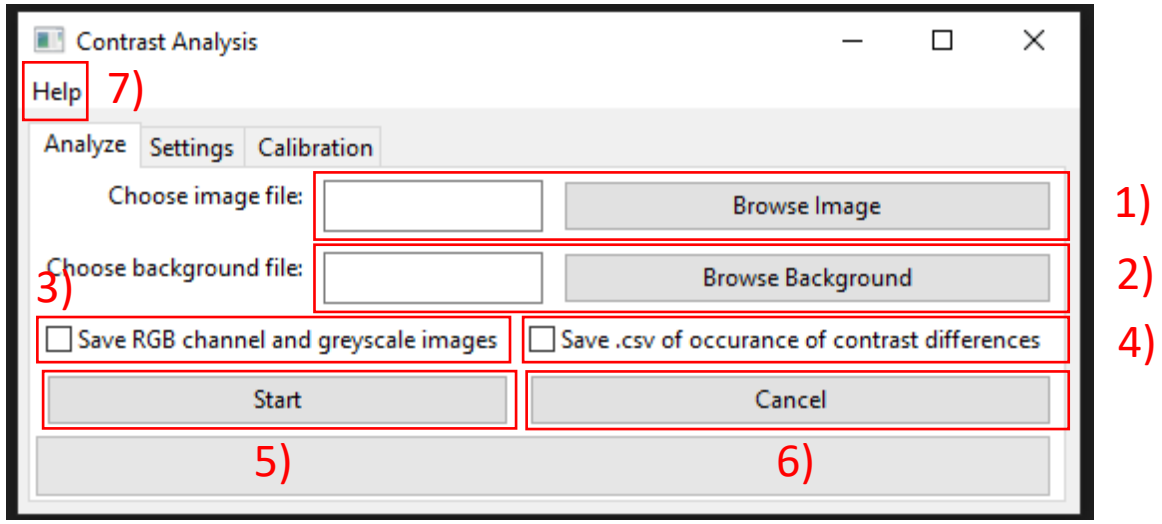
General Information

- This program processes images of few layer Van-Der-Waals materials and determines how thick in terms of layers the sample is
- The software does not need to be installed, when using the executabel.
- To use this software make sure, that the program itself and the SetupDatabase.json file are in the same folder. Otherwise the program will crash or freeze.
- The result of a processed image will always be stored in a folder called „imagename_result“ in the directory where the image is located. No need to copy your files from A to B and vice versa.
- I tried to compensate as much errors as possible, but if you find another one feel free to contact me. I will have a look on the issue.

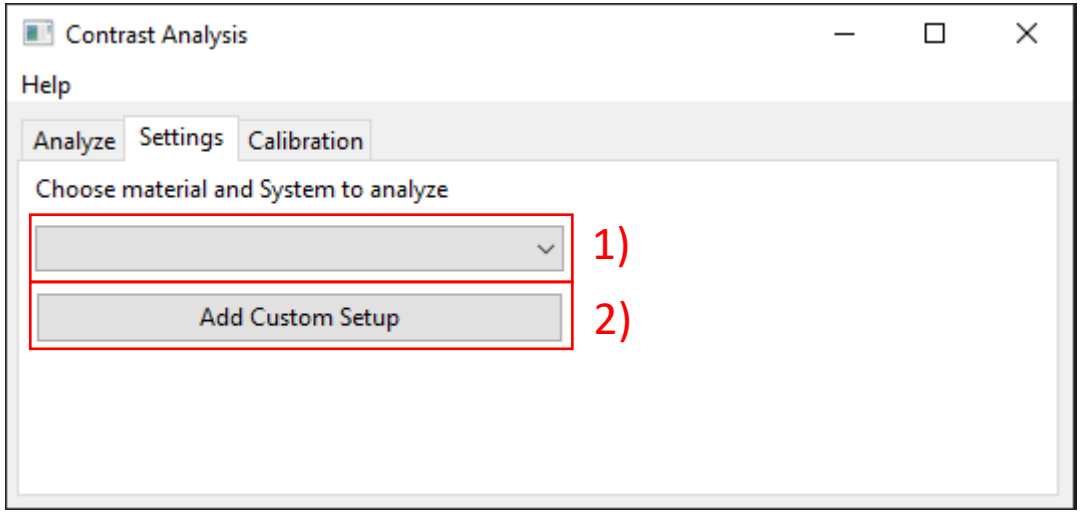
Overview: Analyze Tab

1) Load image by clicking on the button and choose image from the file directory
2) Load background snippet of image by clicking on the button and choose snippet from the file directory
3) Checking will save the individual color channels and a greryscale image of the original image
4) Will save a csv-file of the occurance of the contrast differences
5) Starts analyzing process
6) Cancels process and closes application
7) Dropdown menu containing a small manual and info button



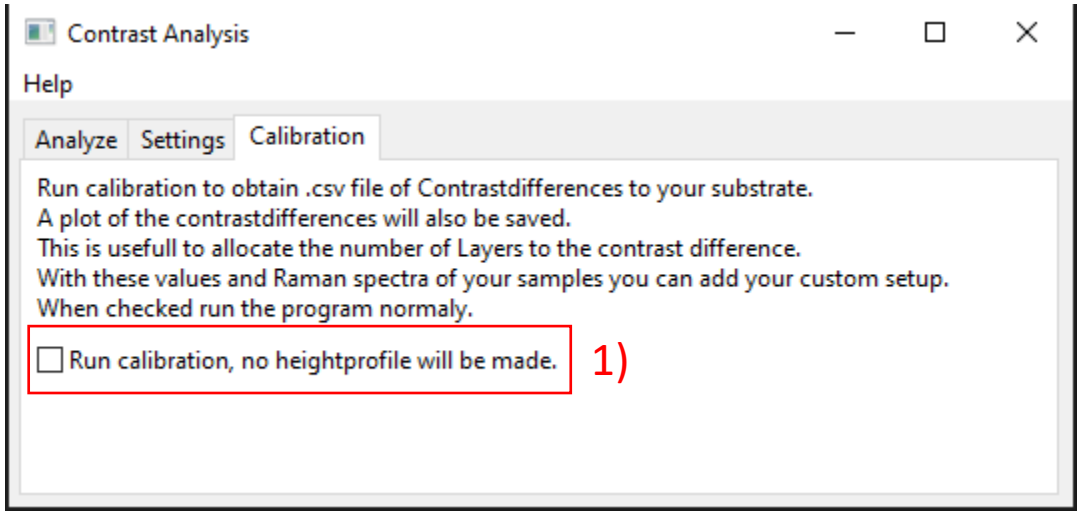
Overview: Settings Tab

1) List to choose the setup settings from
2) adding a custom setup



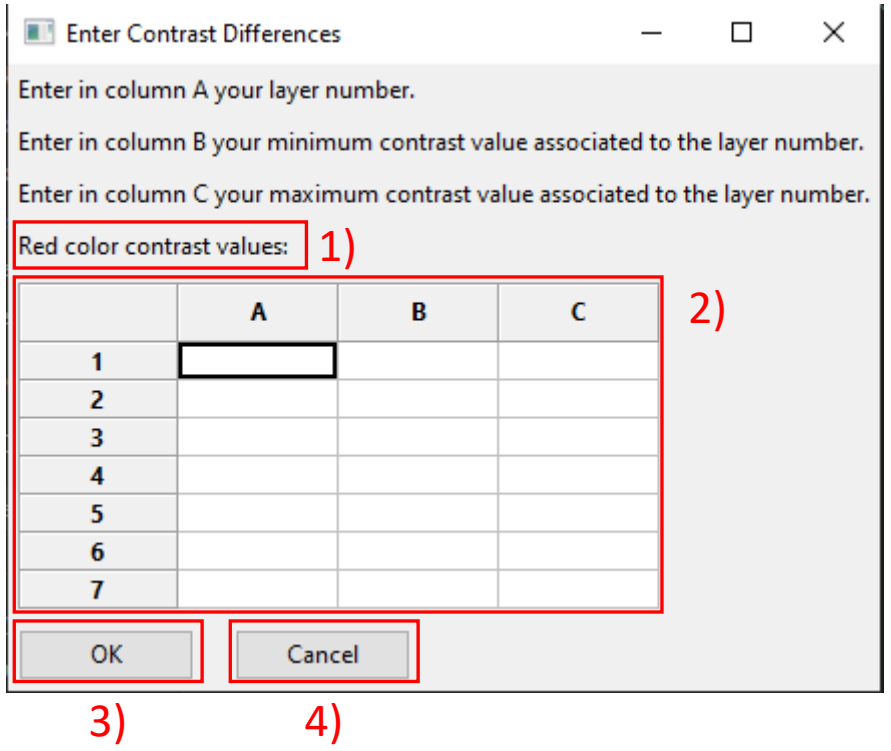
Overview: Calibration Tab

1) Check to perform a calibration run. Obtained data is used for the custom setup.



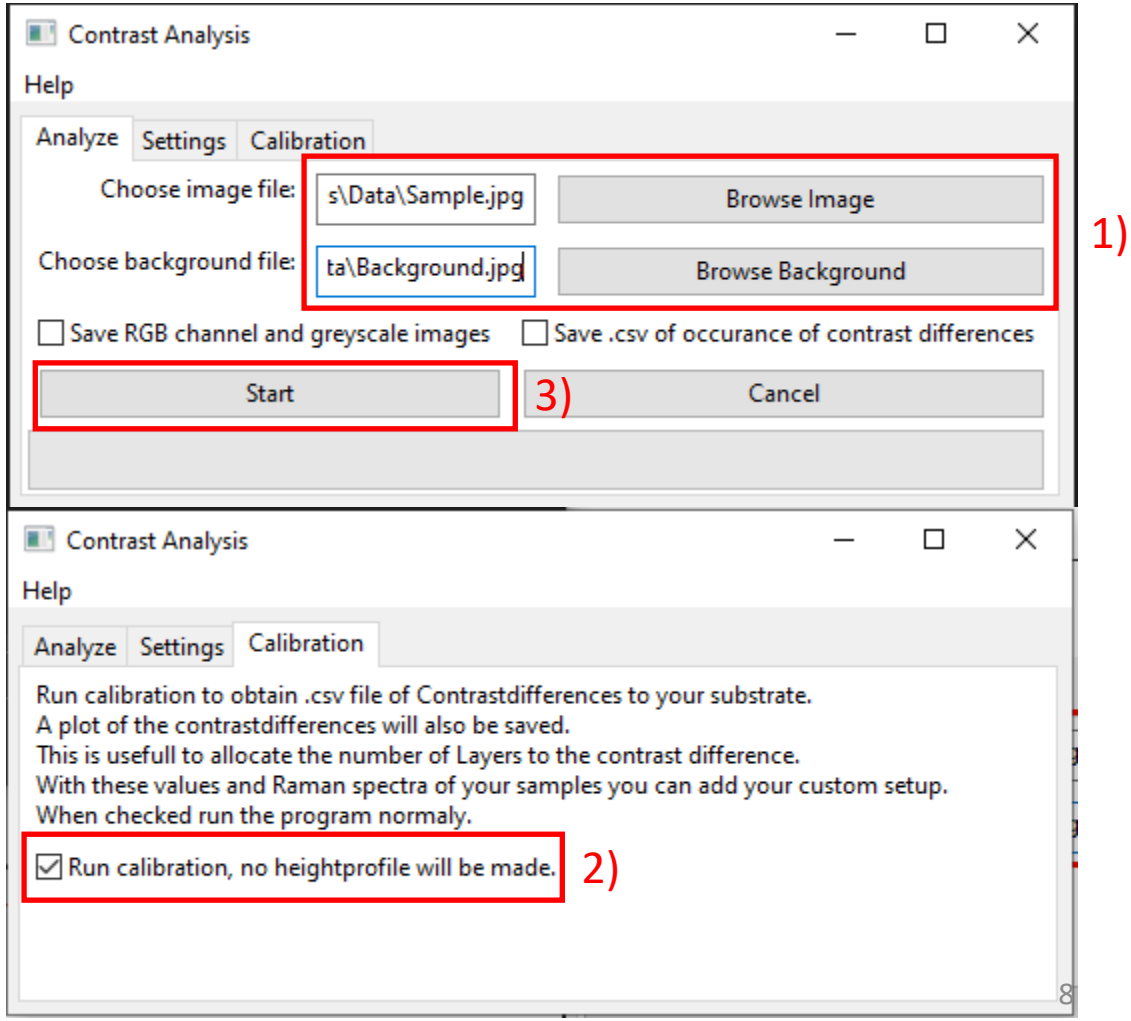
Overview: Spreadsheet

1) Informations field what color values should be added. It is always first red, then green, blue and at last grey
2) Spreadsheet field to enter up to 7 layers
3) Accepts current input for the color, closes after the last one (currently no returning to previous color)
4) Cancel adding process



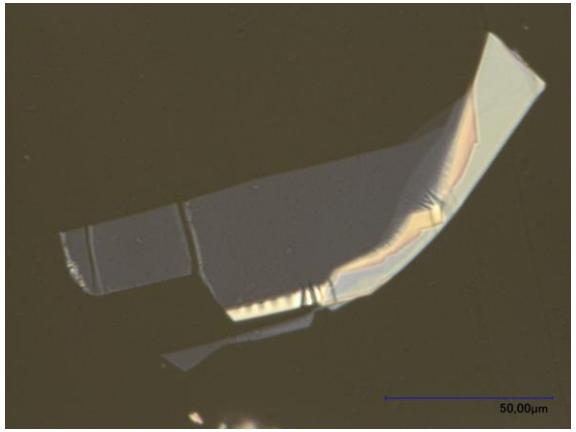
Adding a Custom Setup

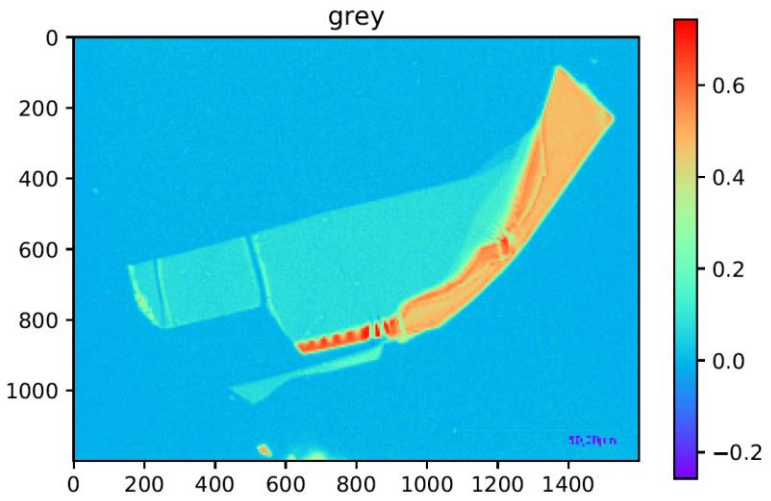
- First you need to load the image and background image in the Analyze Tab
- Image formats that are supported are:
  - .jpg, .png, .bmp, .tiff
- Then you need to check the checkbox in the calibration Tab
- At last hit start



Adding a Custom Setup

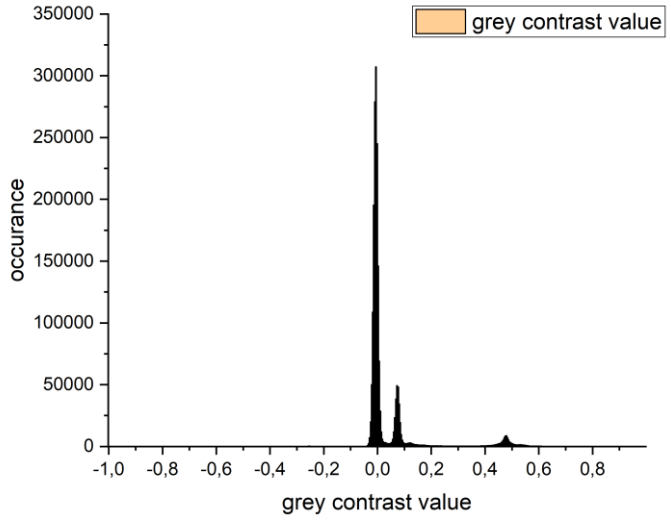
- From the calibration run you will get a folder with two different files per color.
  - First a .csv-file containing the occurance of each contrast value
  - Second a .pdf-file of the image and where the contrast value is found.
  - In total 8 files for red, green, blue and grey
- Here from the image above you would get the lower image for grey

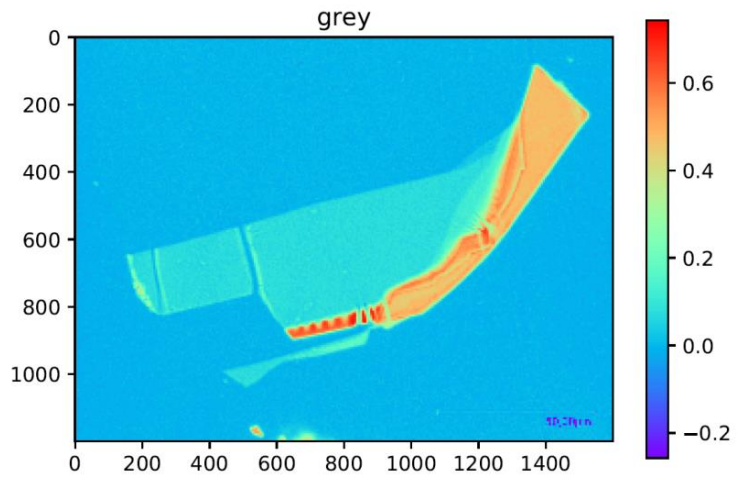




Adding a Custom Setup

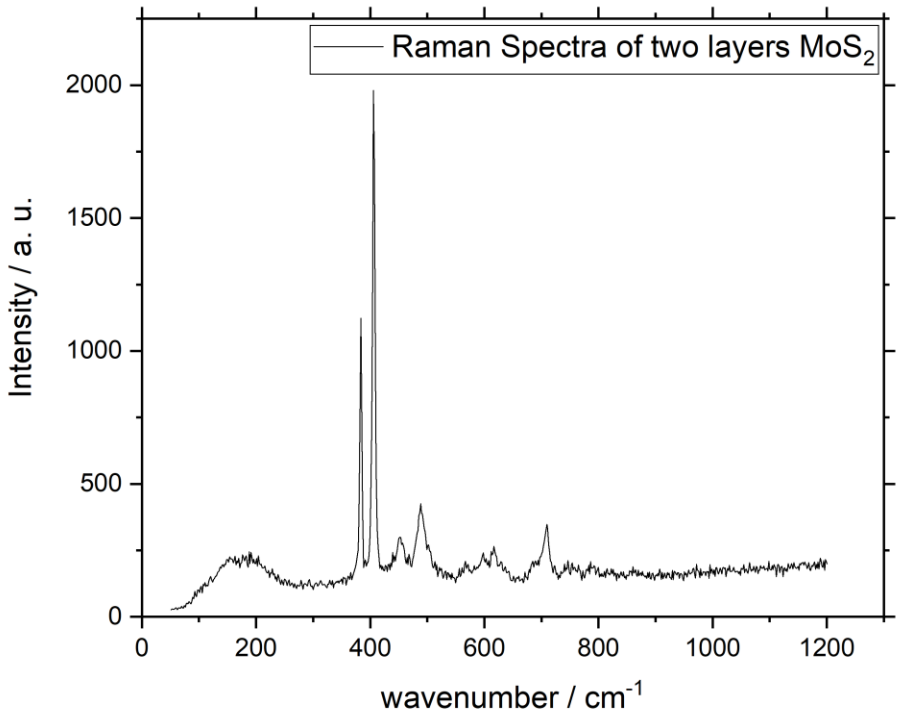
- Plot the csv file with a program of your choice (e. g. Origin)
- You obtain a distribution of different values. The large peak at aorund 0 on the right marks the background.
- It is recommended to do a gaussian fit to find the peak position and the width.
- With the picture below you can assign the contrast value to the region of your sample





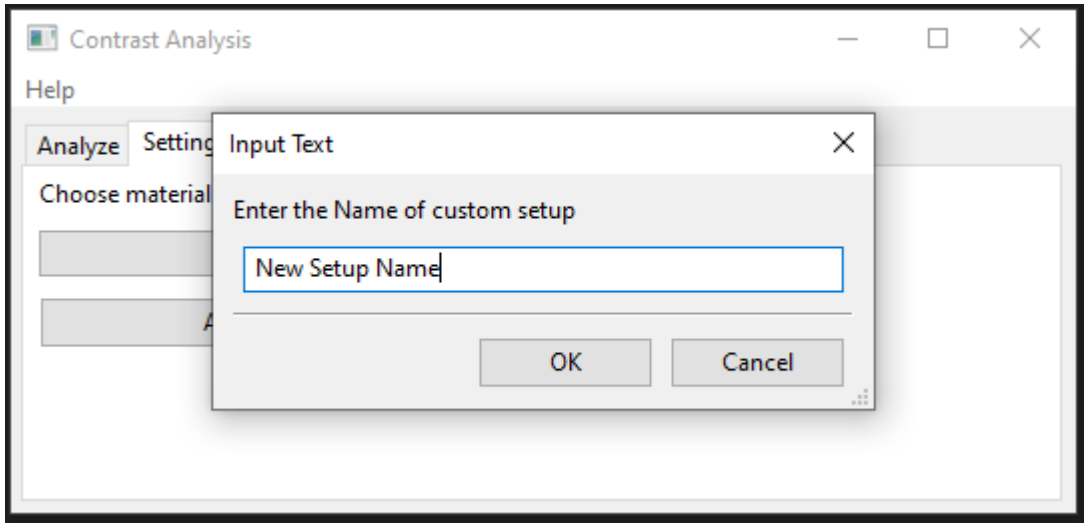
Adding a Custom Setup

- Unfortunately it is necessary to have either Raman spectra or AFM measurements of your samples. With these measurements you can assign the region to the number of layers.
- In this example of MoS_2 we know from the Raman spectrum, that the light blue region is two layers thick.
- When enough data is collected to verify the assignments of different layer thicknesses to a range of contrast difference, the last step can be performed



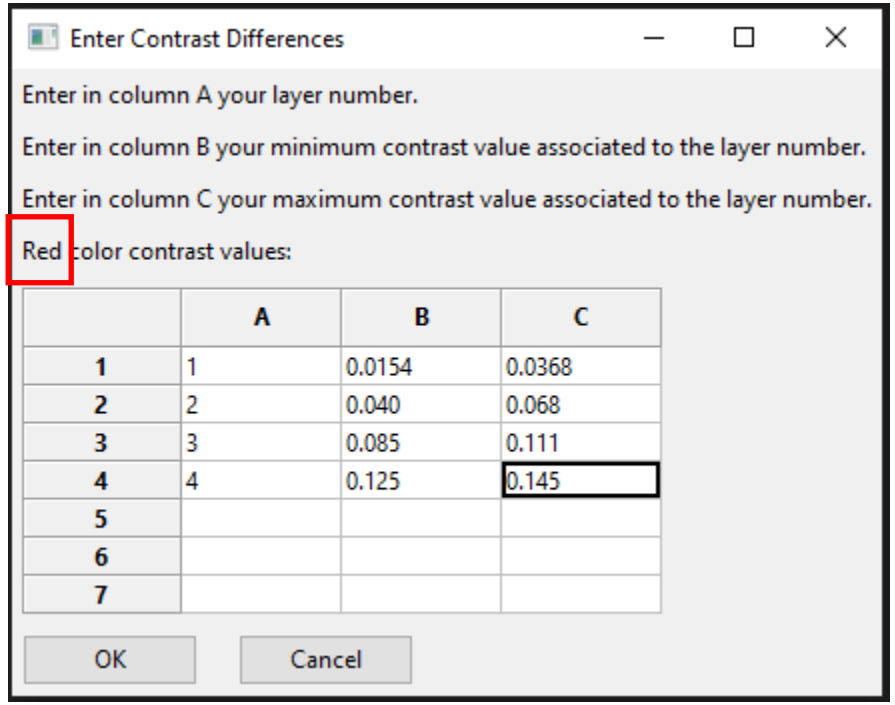
Adding a Custom Setup

- Click on the „Add Custom Setup“ button in the Settings Tab
- A pop up window appears where you should enter the name of your setup.
- Good names consist of the Material and substrate used as well as the settings you took the image at the microscope as these options have a huge influence on the result



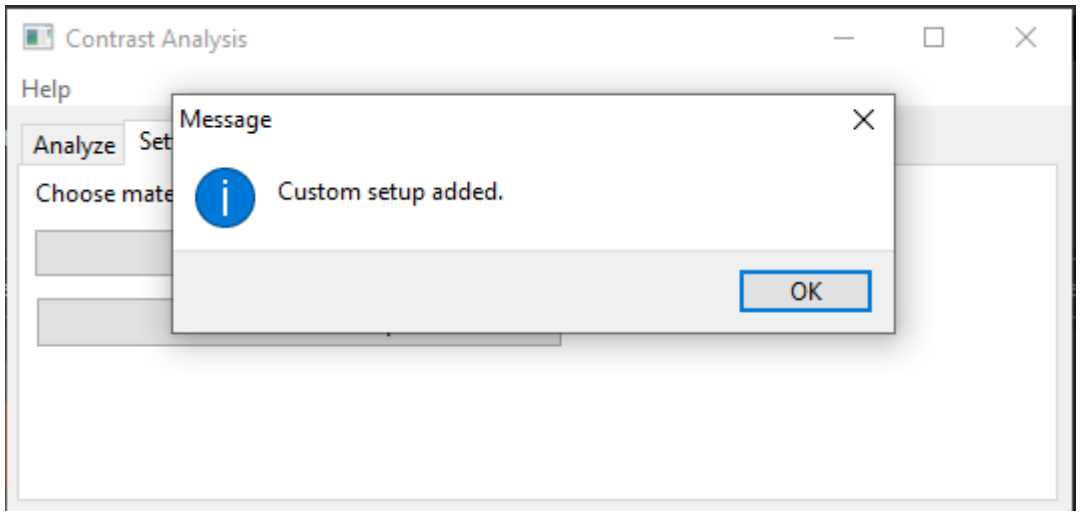
Adding a Custom Setup

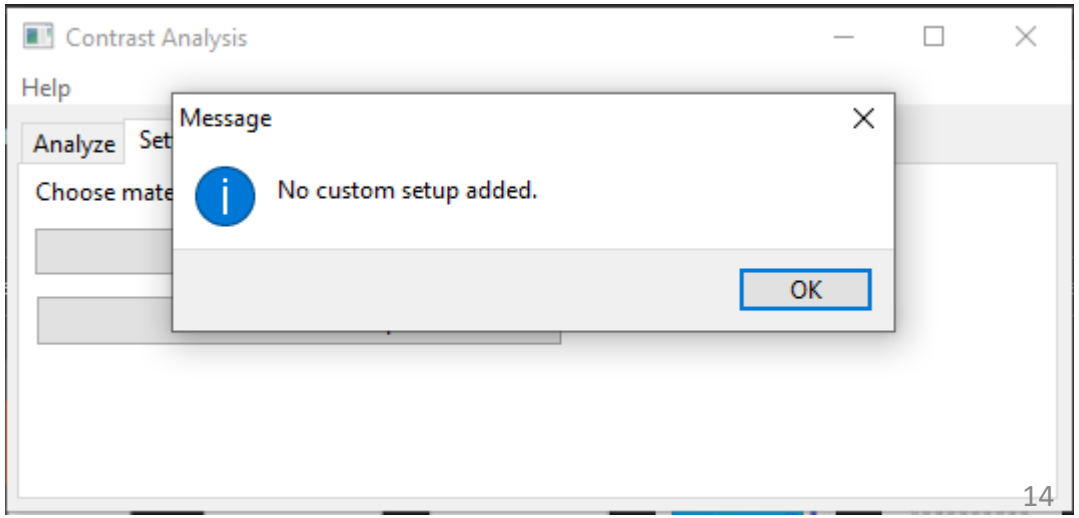
- When „OK“ is hit, a spreadsheet window pops up.
- Here you can enter in column A the thickness of your layer (e. g. 1 monolayer, 2 monolayers, etc.) as shown in the image.
- In column B add the lower border for the layer thickness
- In Column C add the upper border for the layer thickness
- Please use a dot as decimal separator
- The color, marked in the picture, will change each time you hit “ok”
- You can add 7 value pairs but can also just add one or even leave on thickness completely behind



Adding a Custom Setup

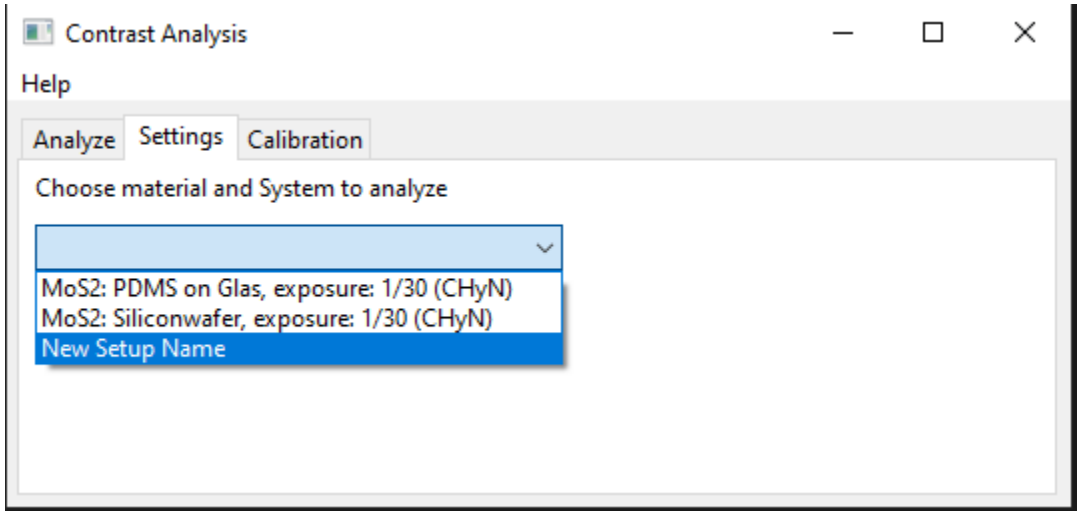
- After a setup was added, a window pops up confirming the new Setup
- When Cancel was hit, a window pops up that no custum setup was added.





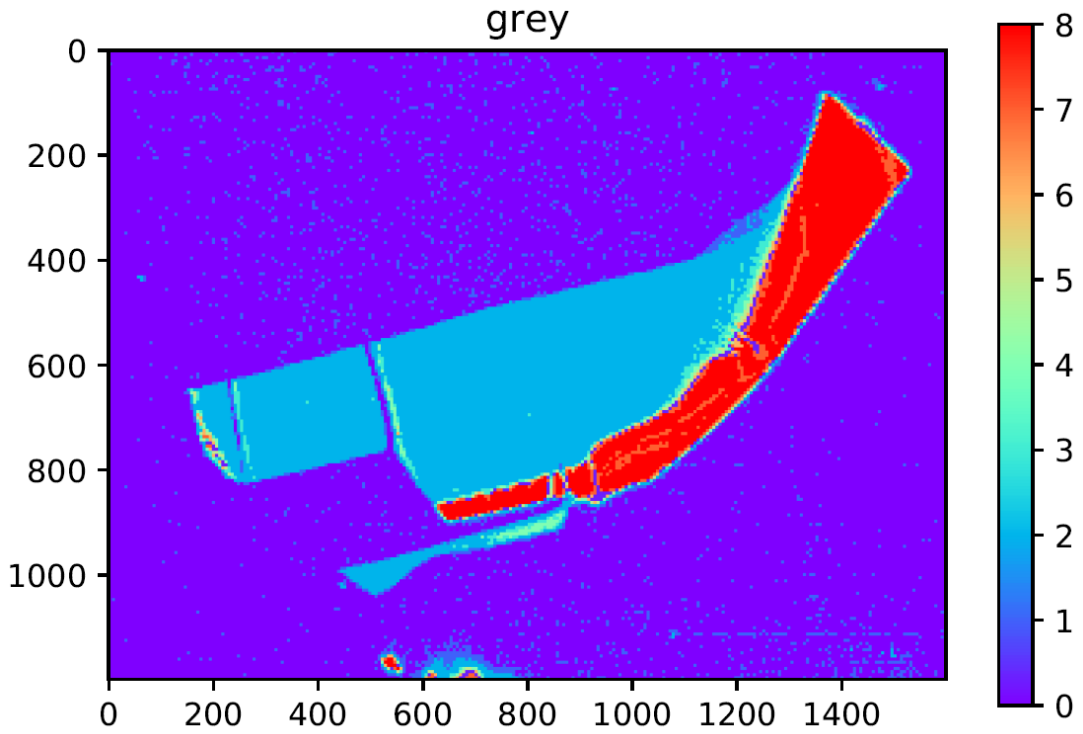
Adding a Custom Setup

- Now the new Setup Can be used and is stored in the „SetupDatabase.json“ file.
- This file is essential for the program to work correct. If it is missing, the program will crash. Please do not manipulate it by yourself. If lost the custom setup is gone and you need to add it again. The file is not created by the program, you need to download it again.



Adding a Custom Setup

- When you run the programm with the custom setup, the result will be a pdf-file showing how thick a region of the sample is.
- The sample here is 2 monolayers thick and has a part which is 8 layers thick or even thicker.



Feel free to use this software for your research. This might be useful tool once it is setup to your needs. When used for publications, cite the software as follows:

Niemann L. (2020), CALAMARI (Version 1.0)[Software], Hamburg, Germany, available at https://github.com/leo-niem/CALAMARI

I appreciate that you are using CALAMARI.

Leonhard Nieman (B. Sc. Nanoscience)