Use of Gwyddion libraries for your little tasks

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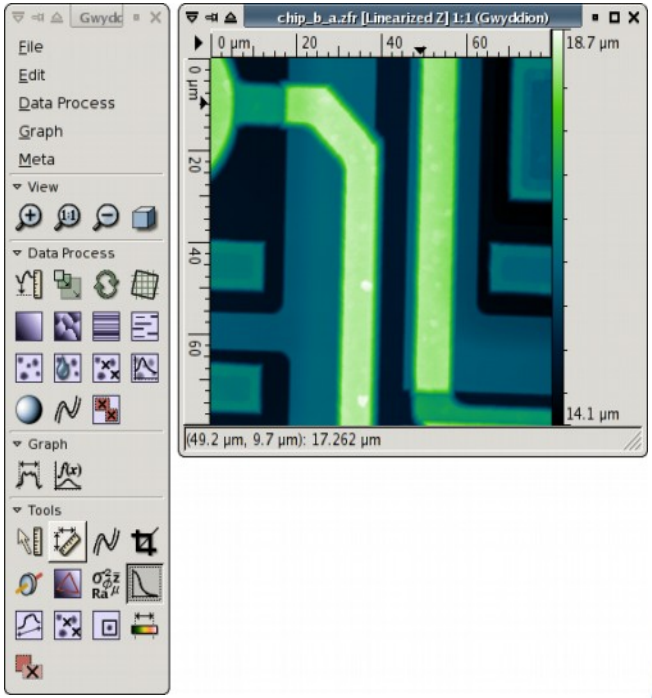
Gwyddion

Open source software for SPM data analysis



Gwyddion is Free and Open Source software for SPM data analysis working on GNU/Linux, Microsoft Windows, Mac OS X and FreeBSD operating systems on common architectures. It aims to provide multiplatform modular program for 2D data analysis that could be easily extended by modules and plug-ins.

Development started in 2003, originally motivated by lack of sufficiently transparent data processing software for metrology purposes.

After ten years it includes support for more that 100 file formats and all the typically used processing routines for SPM data processing (plus many not so typical algorithms as well).

Basic Gwyddion structure

Gwyddion relies on the GLib utility library for portability and uses GLib object system GObject for its own objects. Graphical user interface is implemented with the Gtk+ toolkit, with a fair amount of Gwyddion specific extension widgets.

Gwyddion can be divided into four main components:

1. **libraries**, providing basic and advanced data processing routines, graphical user interface elements and other utility functions and objects,
2. **the application**, quite small and simple, serving primarily as a glue connecting the other components together in a common graphical interface,
3. **modules**, technically run-time loaded libraries, that provide most of the actual functionality and present it to the user, they often extensively use library methods,
4. **plug-ins**, standalone programs that are more independent of Gwyddion than modules, both technically and legally. It should be noted that plug-ins in their current form were found to be a bad idea and while they are still supported it is for compatibility.

Basic Gwyddion structure

The **libgwyddion** library defines some core interfaces, like GwySerializable for data-like objects, GwyContainer, GwySIUnit, GwyResource, etc.

The **libprocess** library defines two basic objects: GwyDataField. representing two-dimensional data and GwyDataLine, representing one-dimensional data. There are many process and analysis functions implemented for these objects.

The **libdraw** library provides colour handling and elementary data rendering functions (gradients, selections).

The **libgwydgets** library is a collection of Gwyddion-specific Gtk+ widgets, like GwyDataView, GwyDataWindow or GwyGraph.

The **libgwymodule** library deals with module administrative, loading and act as a proxy in their usage.

The **libgwyapp** library contains main application related functions (loading, saving, data management, etc.).

What can library functions offer?

Data handling: saving and loading data in full-featured Gwyddion native format, creating single file from multiple data sets of different origin. Also import of more that 100 file formats used in SPM field. (This is a small lie, files are in fact loaded using file import modules behind the scene but all you need to do is use gwy_file_load().)

Data processing: virtually anything that you would like to do with height fields or similar 2D data – morphological operations, spectral analysis, statistical parameters evaluation, etc.

Visualisation: 2D data display in false colors, graphs display, rulers and axes.

Others: data fitting using least squares method, physical unit parsing and arithmetic, ...

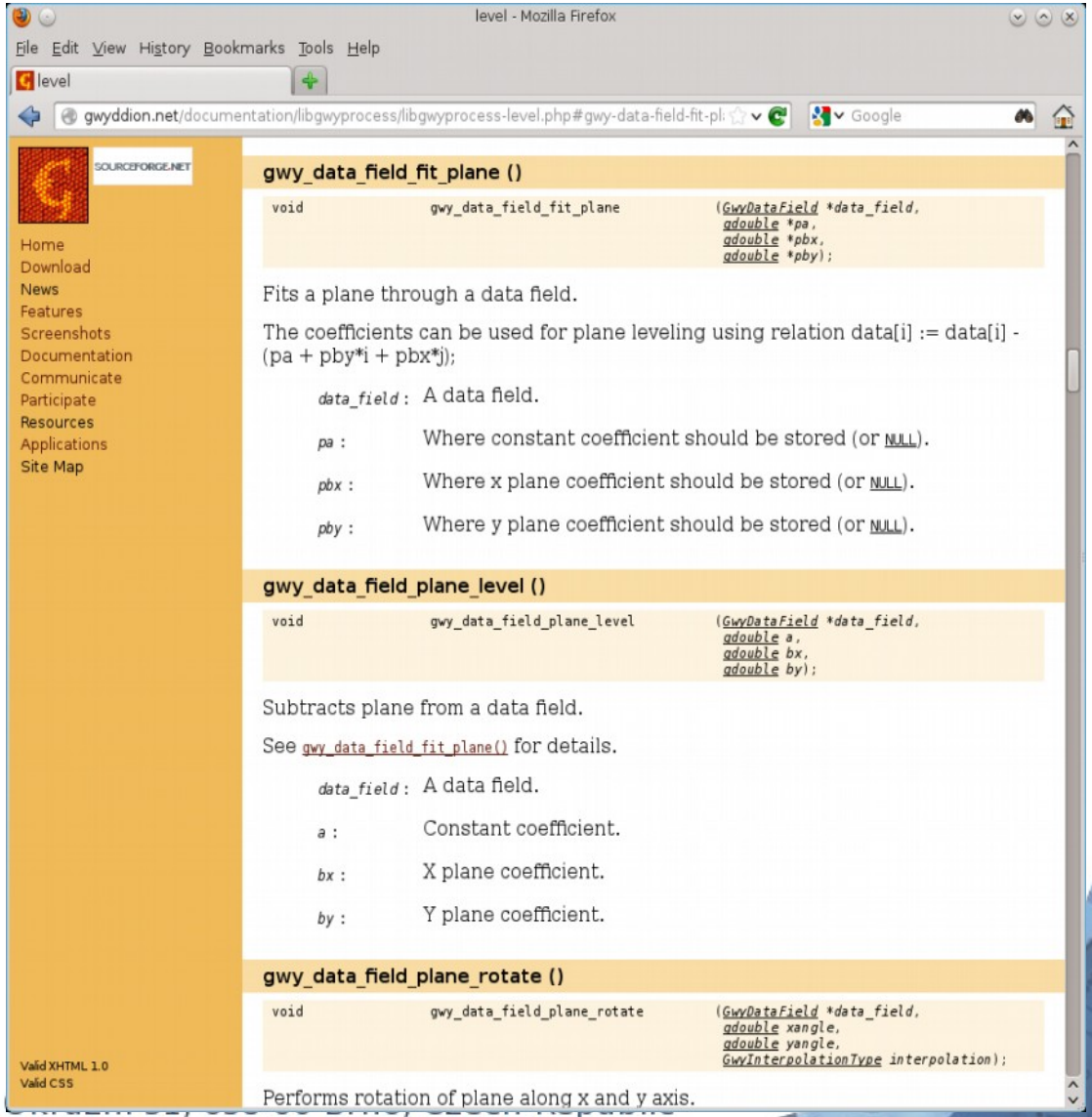
They are easy to use if you are familiar with C, and even easier if you are familiar with Linux and Glib/Gtk programming. A large part of the functions can also be used from Python.

Documentation

All the library functions are documented directly while writing them.

All the libraries are backward compatible within the entire 2.x branch.

Documentation in HTML can be browsed on gwyddion.net or obtained/generated with the source code. It can be also searched and displayed with the DevHelp help browser.



Little tasks in laboratory life

A. Drive custom built instrumentation.

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B. Process custom data obtained from it.

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C. Model something to understand what you have measured.

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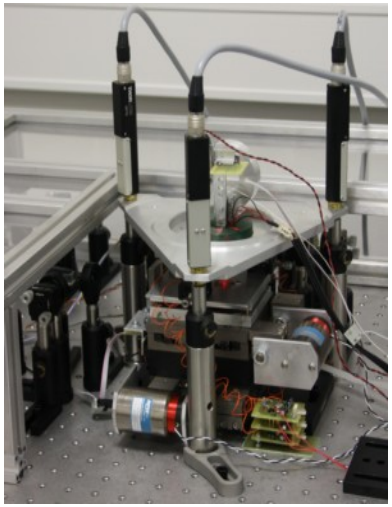
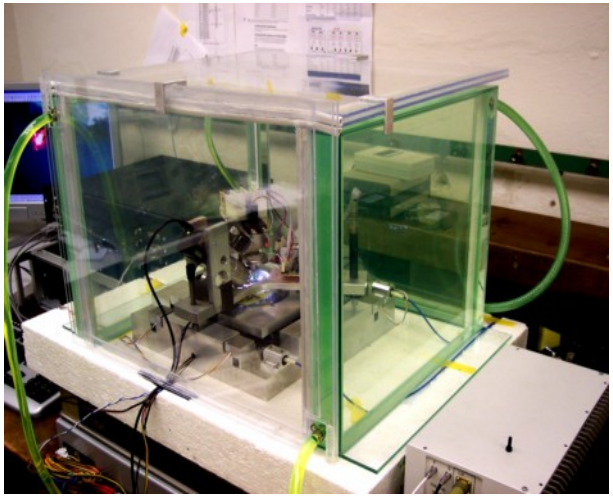
Gwyddion does not solve anything of it, but using its libraries we can do everything much faster.

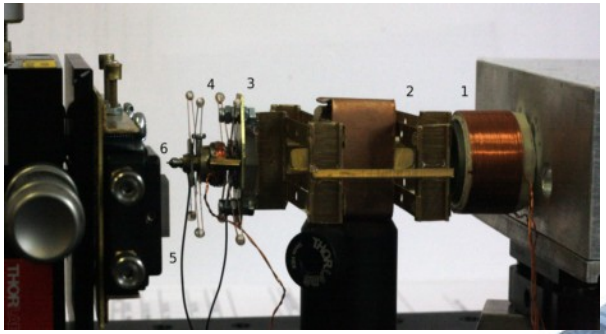
A) custom built instrumentation

Instrumentation development at CMI & CEITEC:

- voice coil based large area SPM instruments
- nanoindentation devices
- spectroscopic digital reflectometry
- special metrology SPM system (with ISI ASCR)
- large area low cost system (with ISI ASCR)





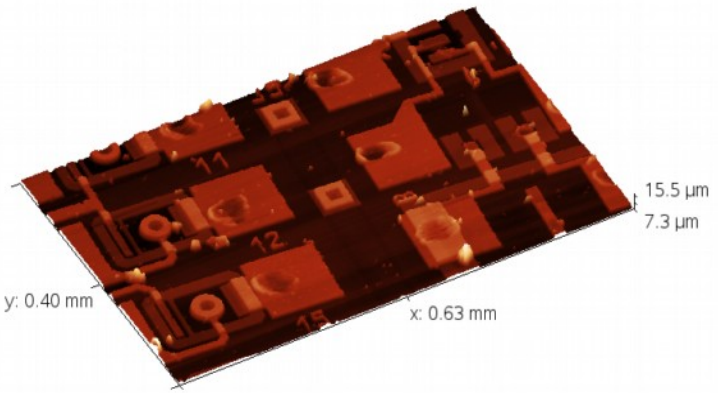


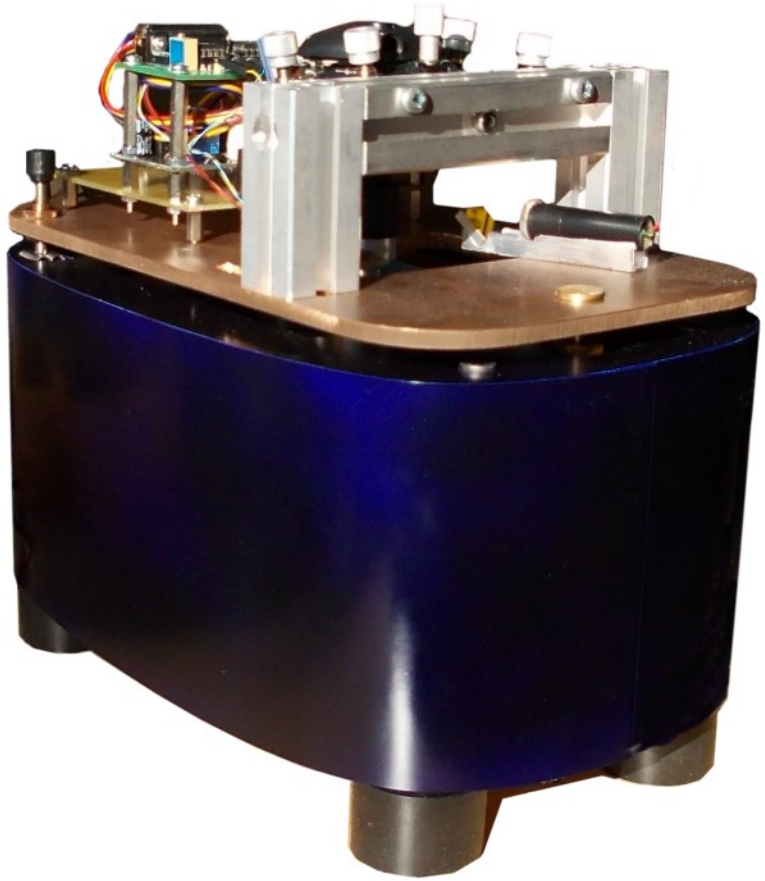
A) custom built instrumentation

Instrumentation development at CMI, ISI ASCR & Mesing

Large area low cost SPM system
based on large area xy table (ISI, Mesing)
and simple conventional AFM head.

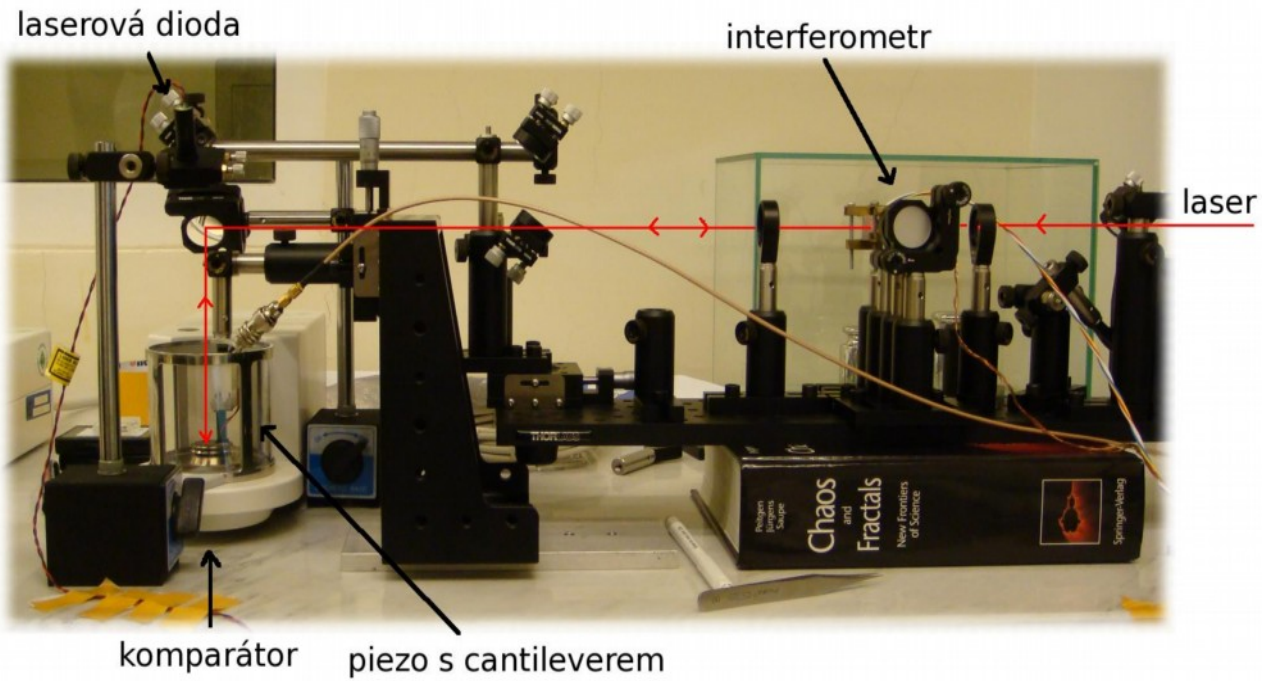
Scanning range up to 1x1 cm, closed loop resolution around 30-50 nm, open loop resolution much higher.





A) custom built instrumentation

Many small custom experiments are needed for all this development.



Example: special device directly employing Chaos and Fractals.

A) custom built instrumentation

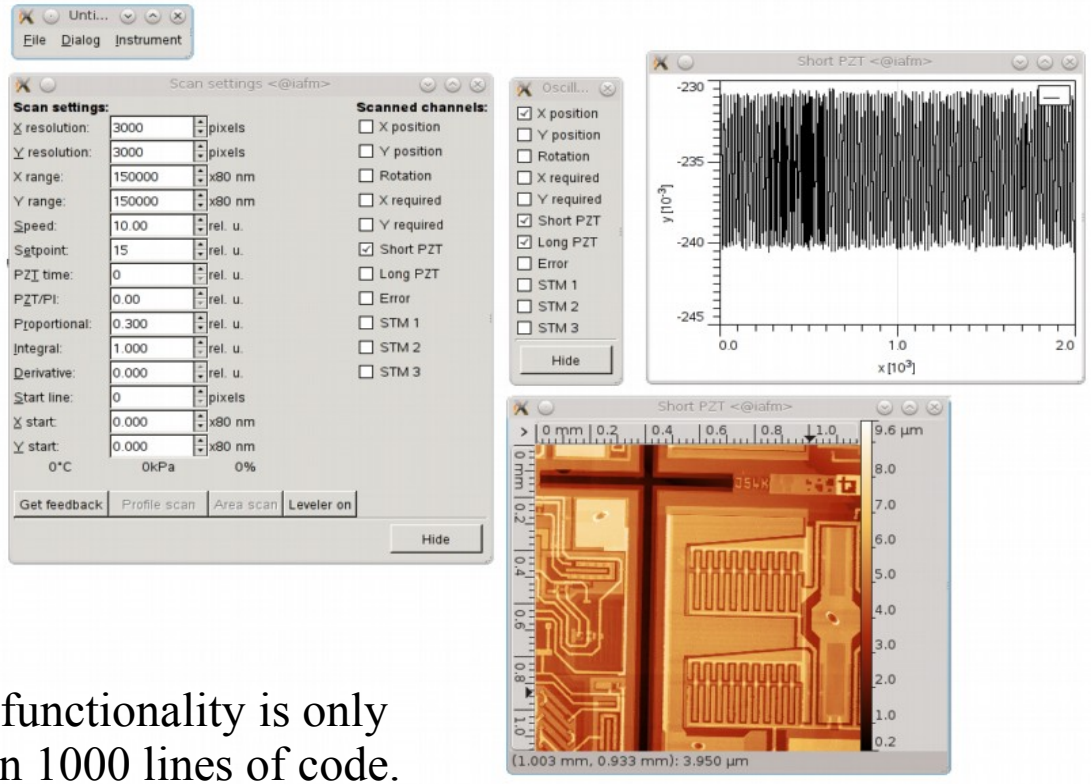
Gwyddion libraries provide data handling and storage, data processing, and graphical interface for 1D (graphs) and 2D (height fields) data visualisation.

Benefits:
- lightweight libraries most data handling in the application
- versatile system applicable virtually to anything

Drawbacks:
- no direct support for data acquisition (like in Labview)
- no direct support for any SPM instrumentation related tasks (like in GXSM)

A) custom built instrumentation

GwyScan is a simple SPM control software based on Gwyddion libraries, compatible with our voice coil, piezoelectric, stick slip and PiezoWalk based SPMs.

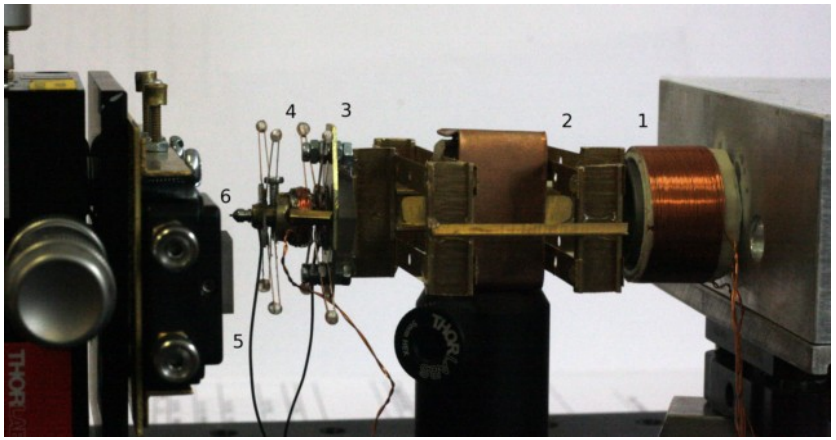


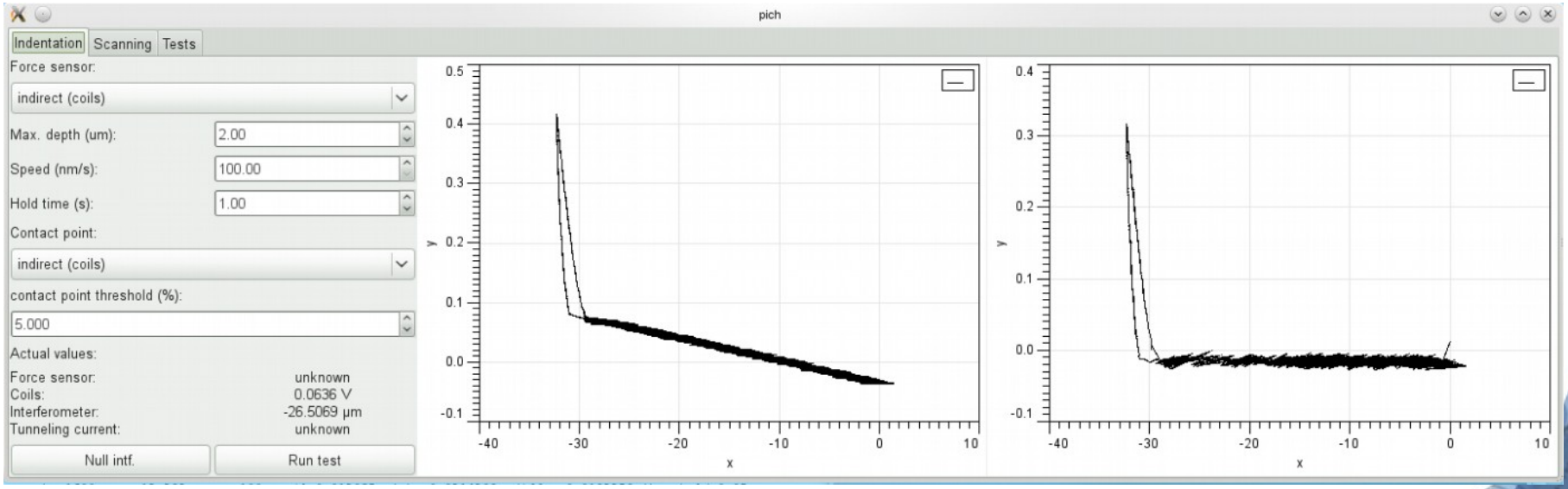
All the hardware related functionality is only a single file with less than 1000 lines of code.

A) custom built instrumentation

Custom built nanoindentation device with direct traceability using differential interferometer.

Gwyddion libraries were used for data handling and visualisation.





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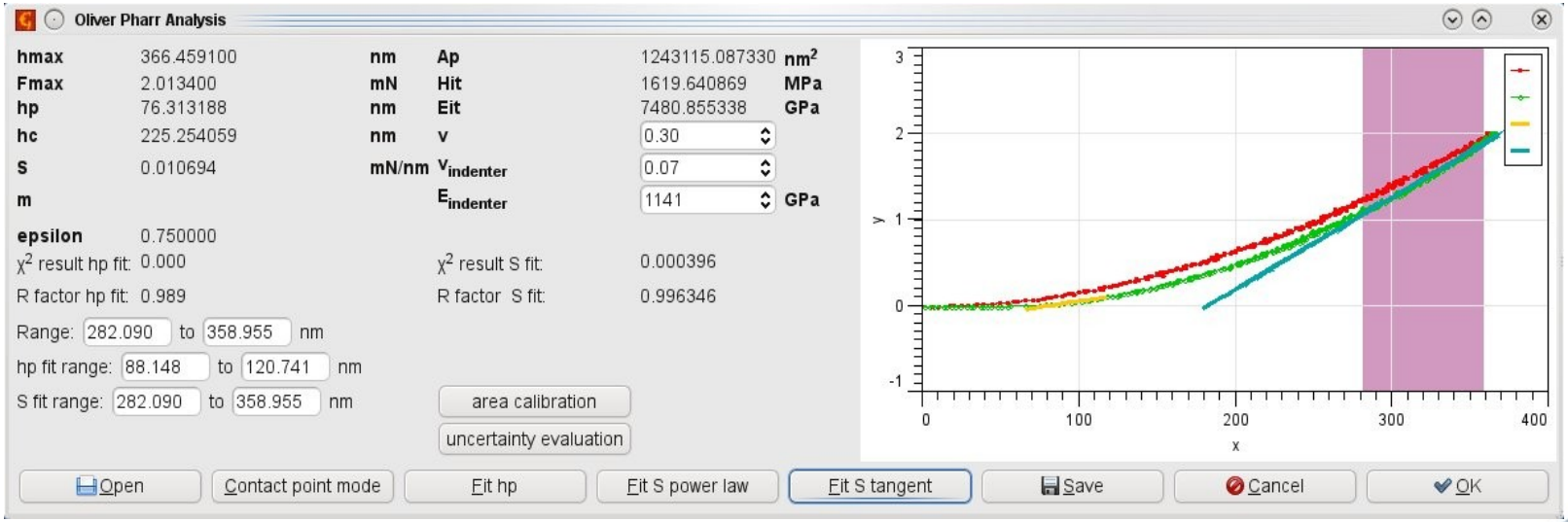
B) advanced data processing

Within Gwyddion framework you can simply build special modules for your specific problems (see the documentation for details how to do this).
It is simpler that you would expect.

For problems not related with SPM at all it is simpler to use libraries only and develop your own binary.



C) numerical modeling

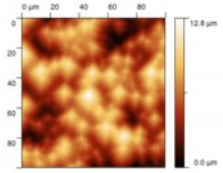
Gsvit is an open source FDTD solver (http://gsvit.net) developed at CMI for microscale electromagnetic field propagation calculations.

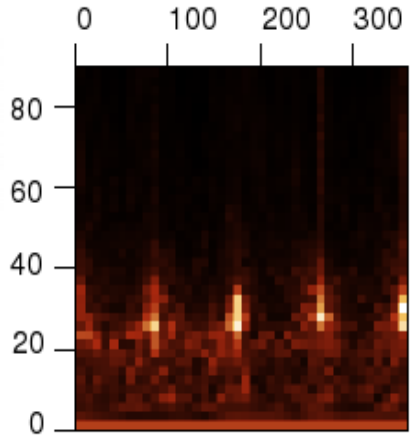
Features:
- running 3D FDTD on processor (CPU) or graphics cards (GPU),
- support for multiple threads on processor,
- up to 80 times faster calculation on GPU than on CPU,
- several graphics cards can be used together, or several programs can be running on different cards,
- use of several Yee algorithm implementations to save memory and time,
- reflecting and absorbing boundary conditions (Liao, CPML), periodic boundary conditions,
- point sources, total/scattered field source,
- time domain Near-Field to Far-Field transformation,
- different materials (linear, PEC, PLRC based),
- predefined database of optical properties for more of 150 different materials

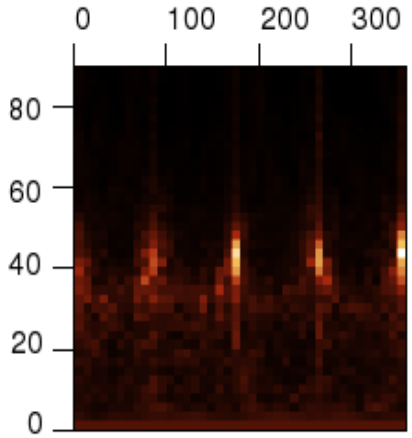
Gwyddion libraries are used for 1D and 2D data treatment within the application and for output of the results. With slight modification, Gwyddion is now able to handle volume data as well.

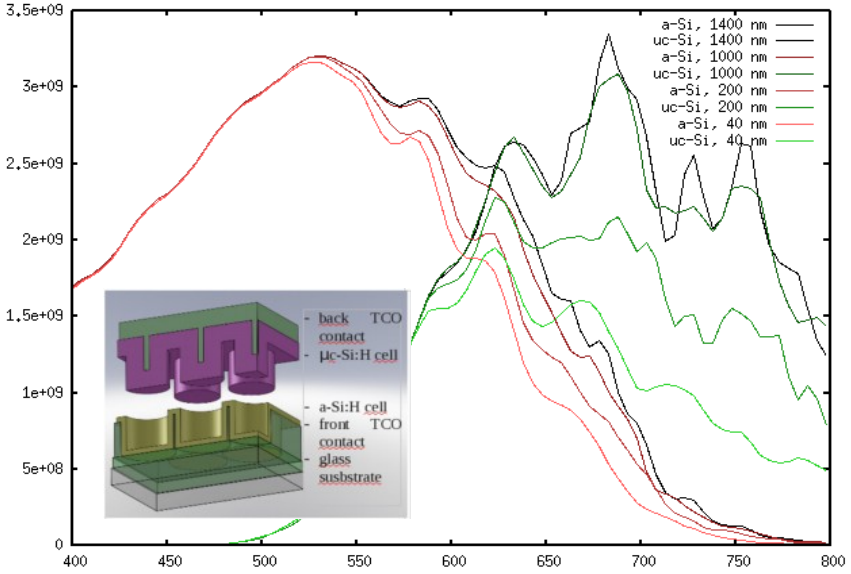
C) numerical modeling

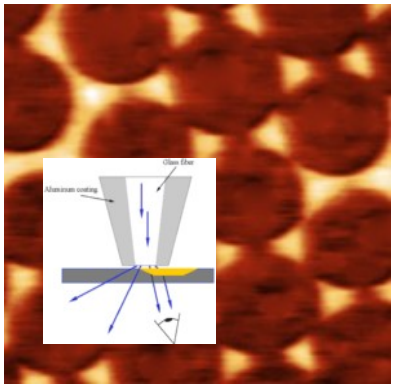
Gsvit so far used for complete SNOM geometry experiment modeling, scattering calculations from rough surfaces and for microstructured solar cell efficiency optimisation.

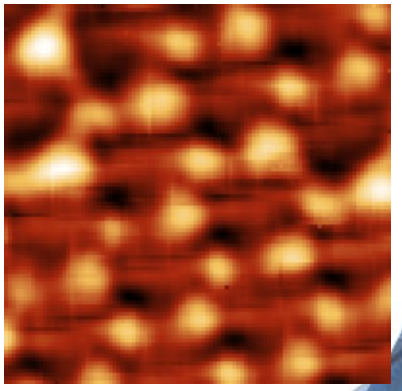






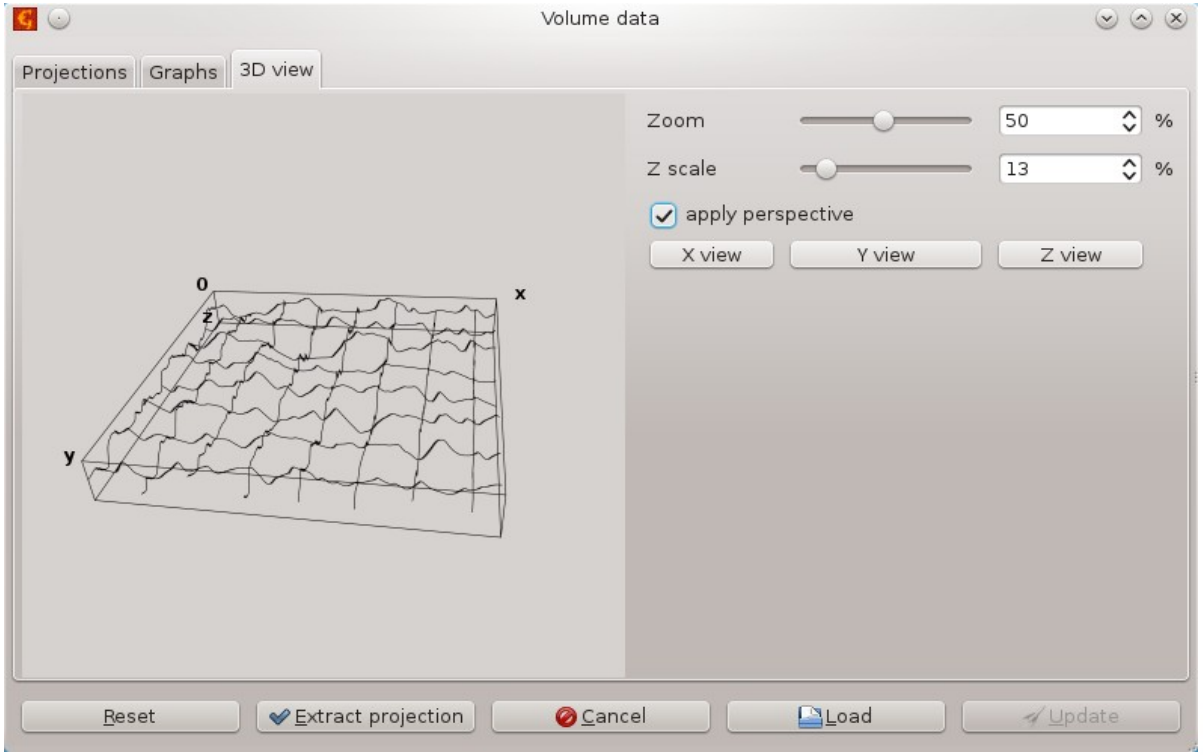






C) numerical modeling

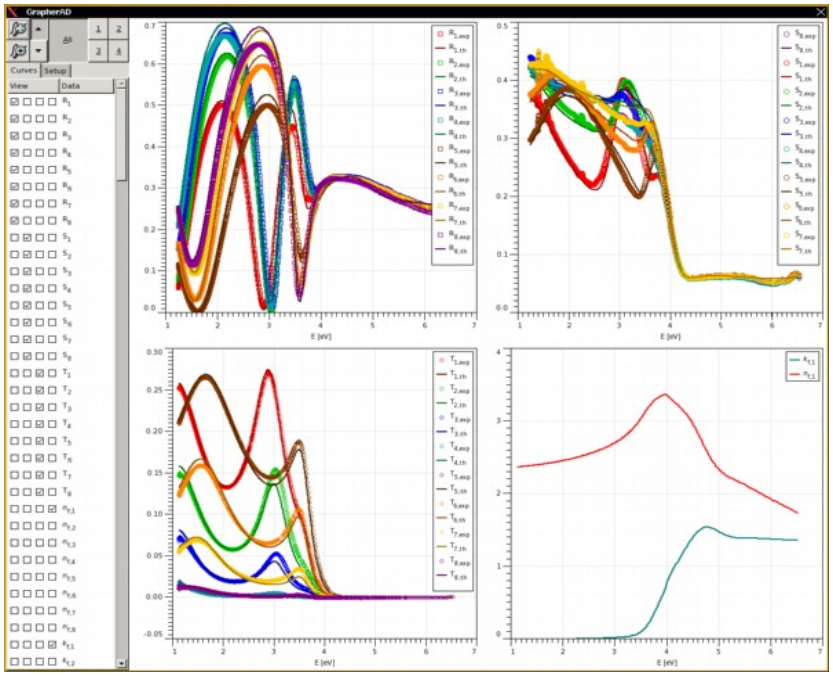
Besides 1D and 2D data treatment from Gsvit we are developing a general 3D data handling module for Gwyddion, which should be useful also for other data, not only for FDTD, e.g. for force volume data from AFM.

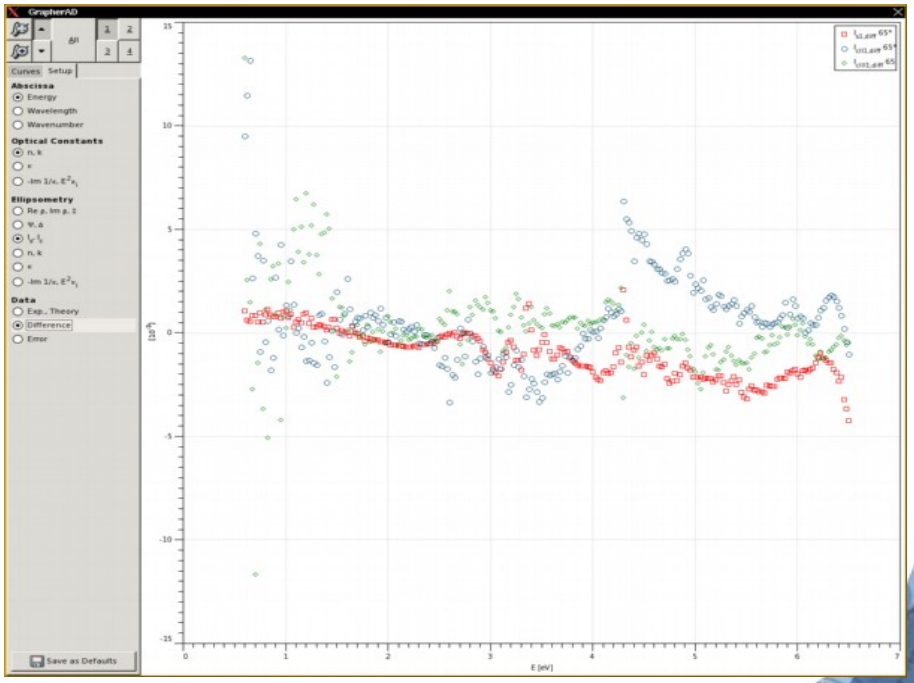


D) something completely different

GrapherAD is a graphing monitor for a custom spectroscopic ellipsometry and spectrophotometry data fitting software used at Plasma Technologies group of CEITEC, Masaryk University.

It uses Gwyddion widgets (namely graph widgets) for visualisation.



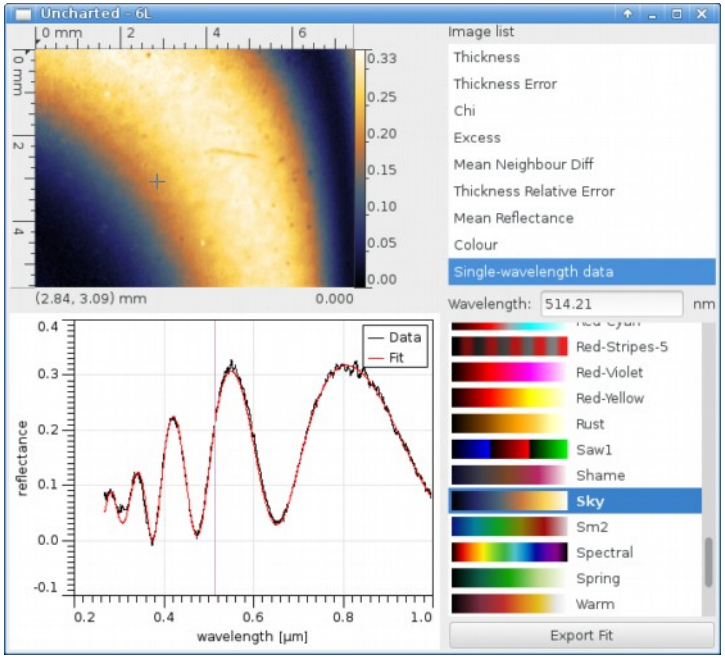


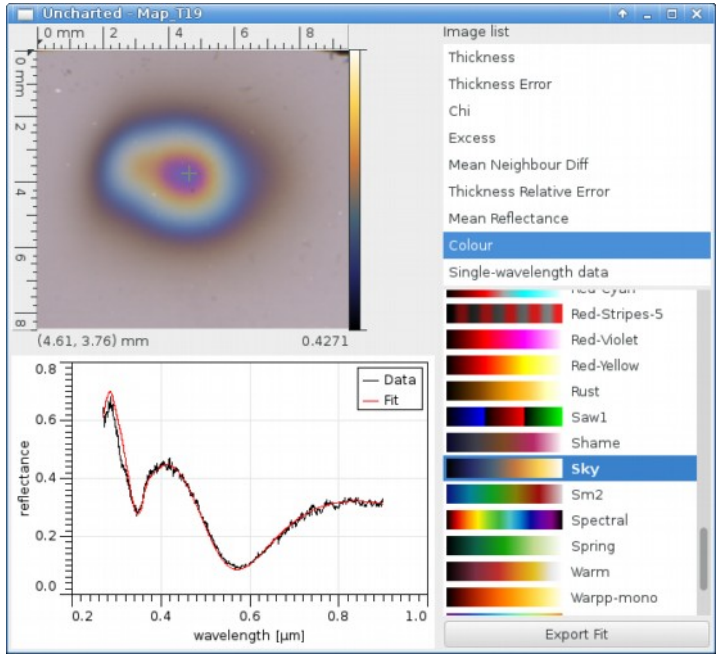
D) something completely different

Uncharted is a imaging spectrophotometry data visualisation software also used at Plasma Technologies group of CEITEC, Masaryk University.

It uses Gwyddion widgets for visualisation.

The data are fitted using another Gwyddion-based program (command line, nothing to show here).





Conclusions

Gwyddion libraries can be used to employ most of the Gwyddion functionality in your applications.

They can be used on all the major operating systems, do not need anything external besides Gtk+ related libraries and are open source under GNU GPL.

They can solve many small and time consuming tasks concerning data management, processing and visualisation, leaving for you only coding of the most challenging part – key application functionality.