Measurement in SemiContact regime using scanning probe microscope SolverNext

Theoretical part:

1. Explain basic principle of the measurement in SemiContact regime. On the force-distance curve highlight the region utilized for the measurement in SemiContact regime.
2. Explain the principle of the phase contrast in the SemiContact regime.
3. Compare the characteristics of cantilevers employed for the measurement in Contact and SemiContact regime.

Experimental part:

Task:

Perform the measurement of sample using the atomic force microscope operating in semicontact regime, in mode with constant amplitude.

SolverNext microscope:

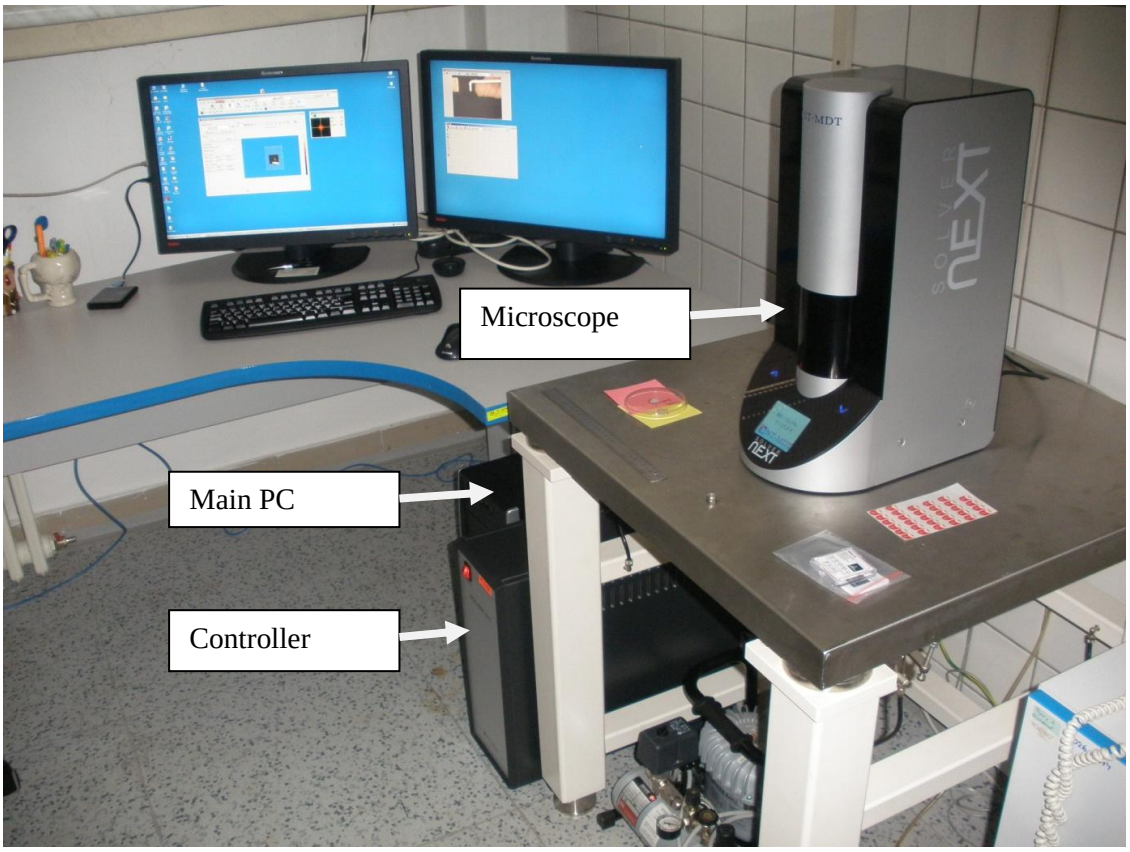


Fig. 1 SPM system SOLVER NEXT

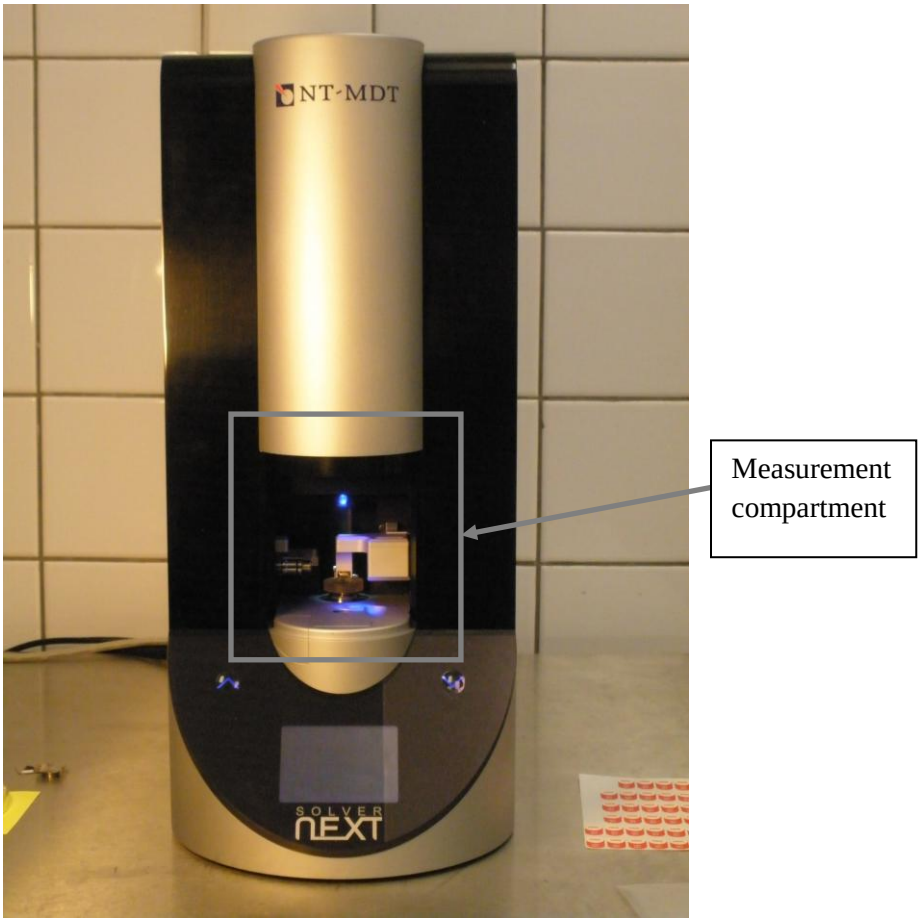


Fig. 2 Detail of the microscope body

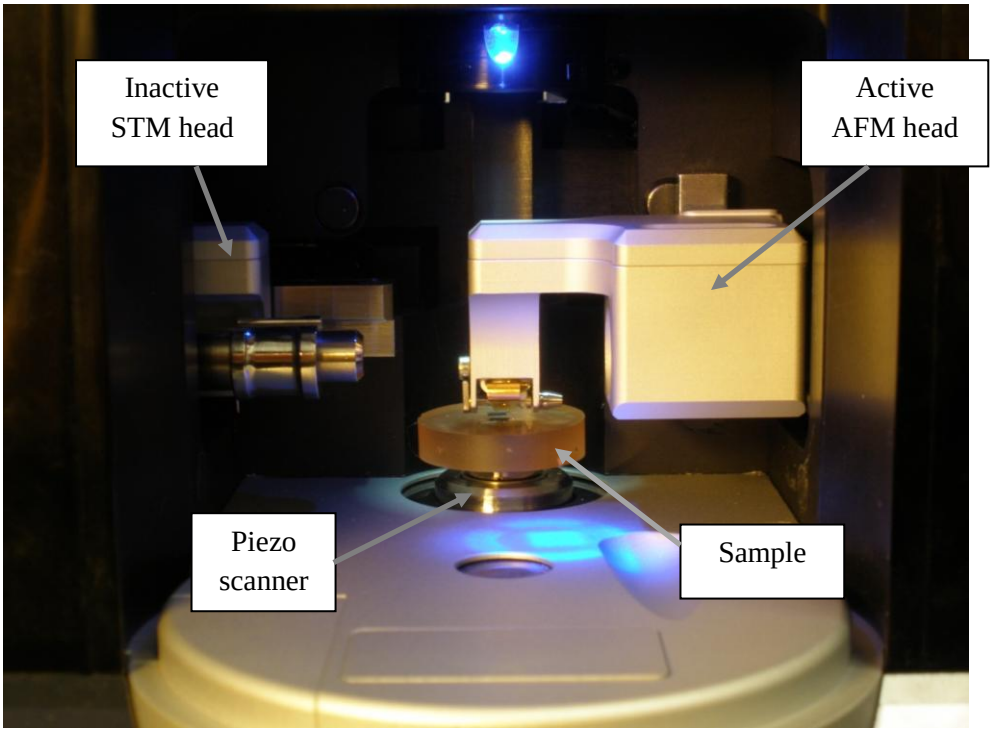
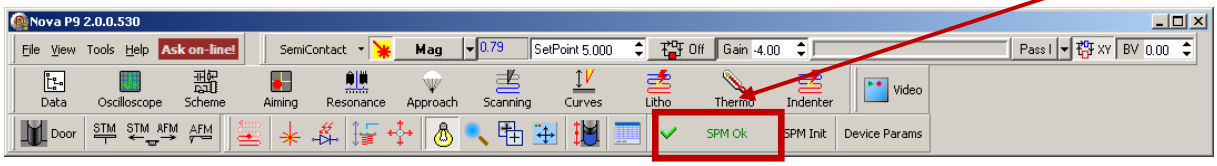


Fig. 3 Detail of the measurement compartment

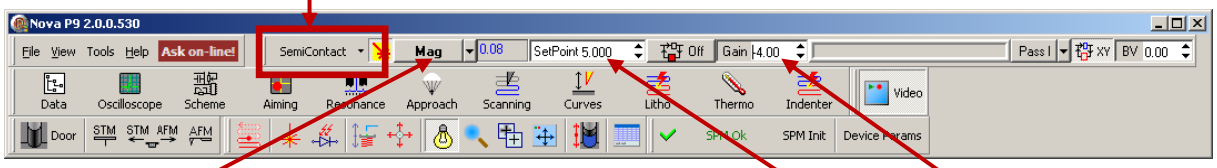
Measuring procedure:

1. Initialization of the SolverNext SPM microscope.
    a. Turn on "Main PC" (Fig. 1)
    b. Turn on "Controller" (Fig. 1)
    c. Start up the Nova_P9 program. The initialization of SolverNext SPM microscope runs automatically, initialization is finished when message "SPM OK" appears.



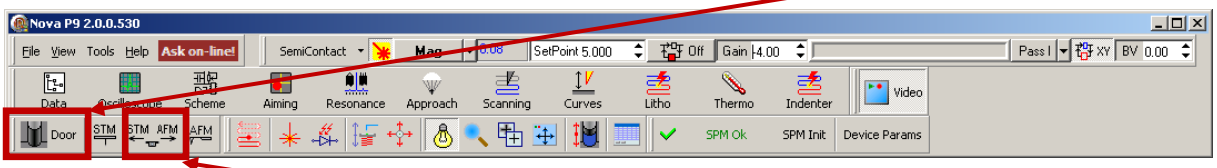
    d. The preparation of the measurement in selected regime is now possible. Follow carefully next procedures for successful measurement!

2. Select "**SemiContact**" regime.



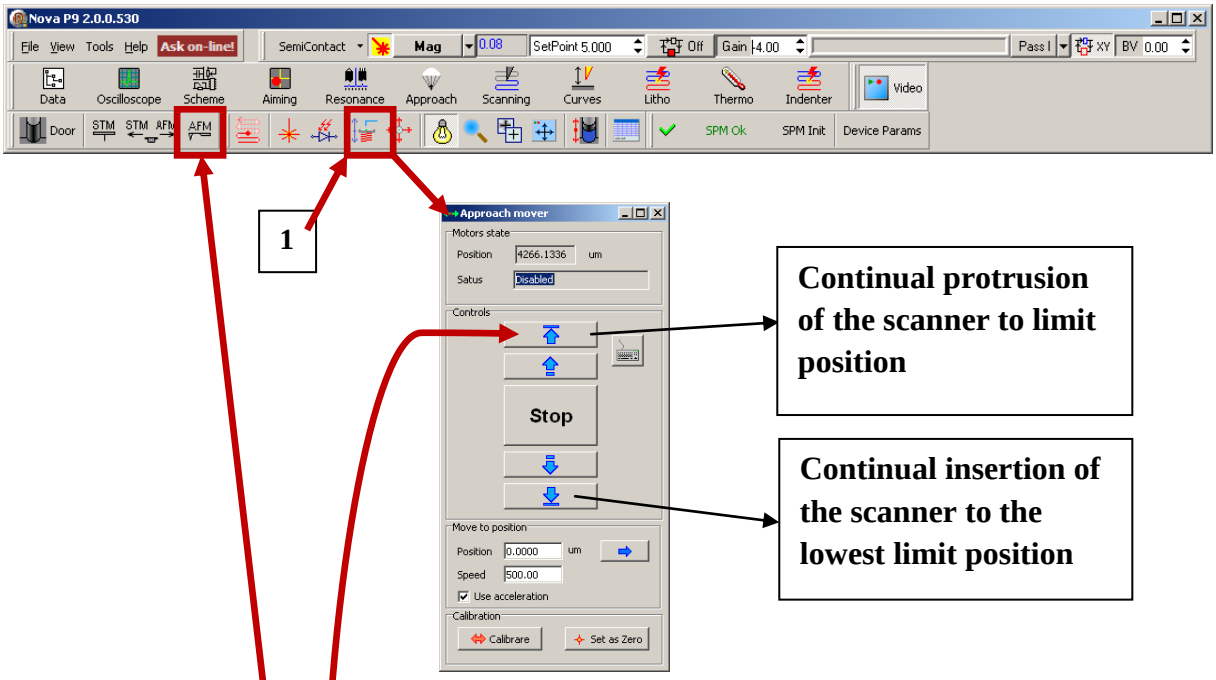
After the "SemiContact" regime selection the main parameters are set automatically (**Mag** measuring mode is set … in this mode the magnitude of the oscillating cantilever is kept on the constant value during the measurement, initial value "5" of **SetPoint** is set … this value gives the decay of the magnitude of the vibrating cantilever. The initial value of **Gain** "-4" is also set automatically … this parameter reflects the speed of feedback, the higher the Gain value, the faster the feedback response. These parameters can be adjusted during the measurement to obtain the image of surface with desired quality.

3. Open the door of measuring compartment by pushing the icon ***Door***



4. Control the position of AFM measuring head (see Fig. 3). If the head is pushed forward, perform its insertion by clicking on the icon ***STM AFM***.

5. Check the scanner position (see Fig. 3). If the scanner is pushed forward perform its insertion. If this controlling is omitted the AFM head can strike the sample and the measuring tip can be destroyed. Perform the Scanner insertion:
   Push the icon assigned by number 1, the window which enables moving of the scanner in **z** direction is activated; push the down arrow allowing continual insertion of the scanner to the lowest limit position. Place the sample on the Scanner.



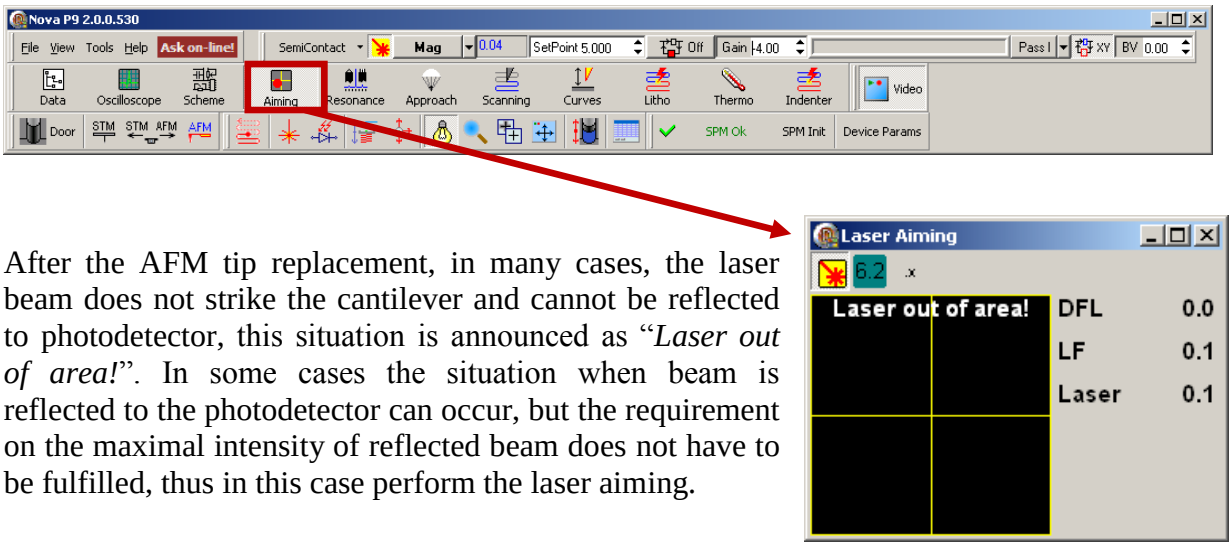
6. Perform the protrusion of the AFM head by the clicking on the icon ***AFM***.

7. To change the tip, ask assistant for instructions.

8. Perform the protrusion of the scanner, during the scanner protrusion **control** !!! the distance between the AFM head and sample surface; if the distance is about 2 mm stop the drawing-out process.

9. Close the door (the same procedure described in paragraph 3).

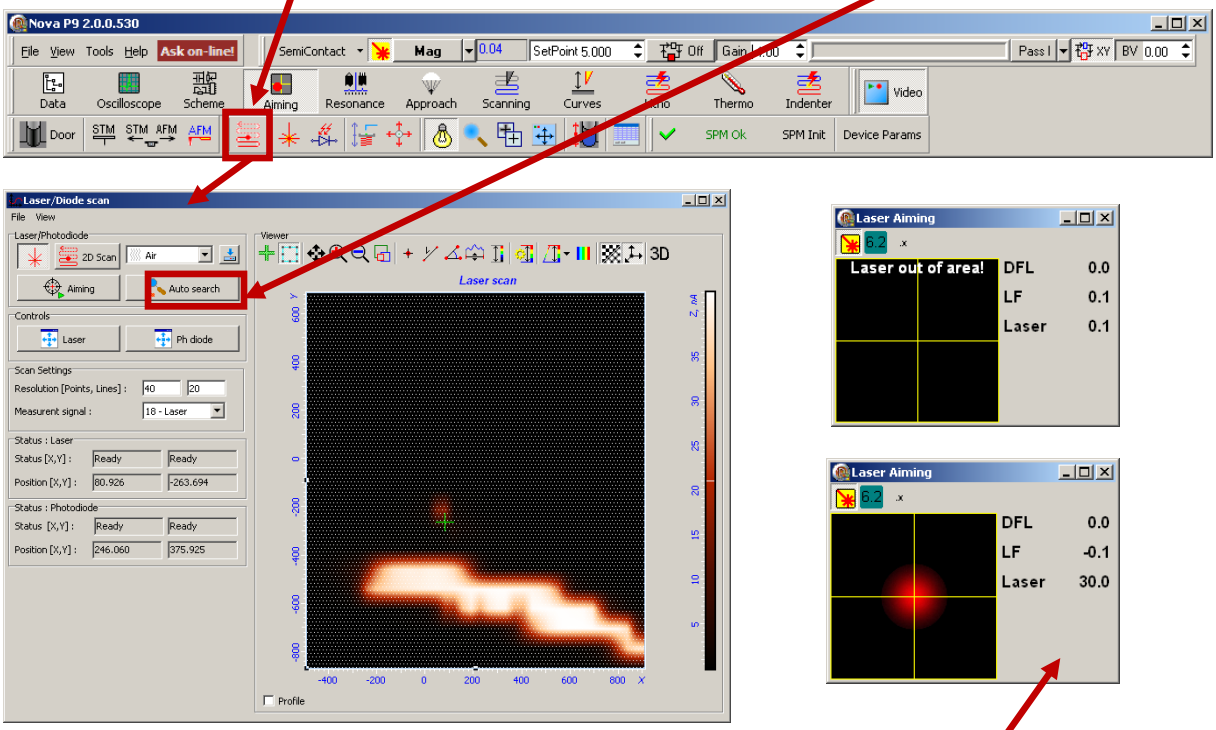
10. Perform automatic aiming of the laser. Click on the icon ***Aiming***, the window **Laser aiming** is activated and schematically shows the position of the laser beam stroked on the photodetector.



After the AFM tip replacement, in many cases, the laser beam does not strike the cantilever and cannot be reflected to photodetector, this situation is announced as "*Laser out of area!*". In some cases the situation when beam is reflected to the photodetector can occur, but the requirement on the maximal intensity of reflected beam does not have to be fulfilled, thus in this case perform the laser aiming.

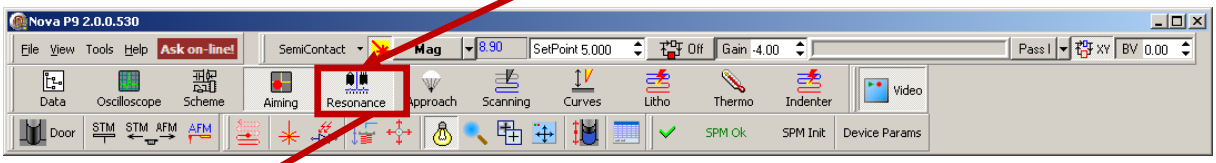
Perform the following laser aiming:

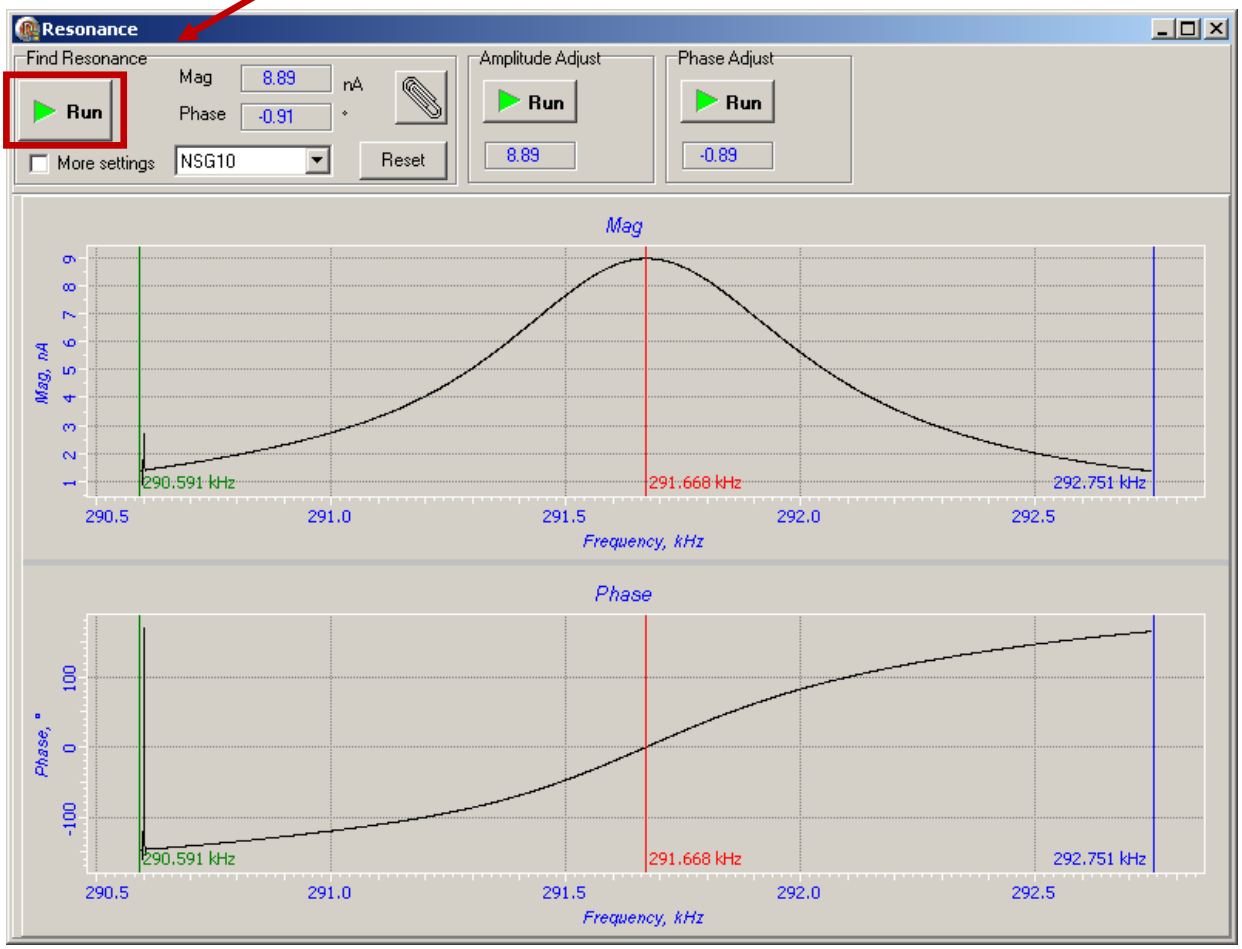
Press the icon ***Laser/Diode Scan***, the window for the laser aiming occurs. Perform the automatic search of the optimal hardware configuration by procedure ***AutoSearch***.



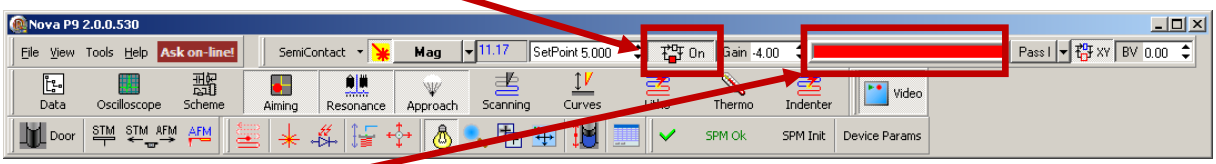
After the successful aiming the window "***Laser Aiming***" will appear as follows. If the procedure AutoSearch fails, ask the teacher for assistance.

11. Perform the automatic search of resonance frequency of given cantilever. For the initialization of searching procedure click on icon ***Resonance***, in newly appeared window push the green button ***Run*** and start automatic search of the resonance frequency. Compare this procedure with the same procedure implemented in older system EXPLORER^{TM}.



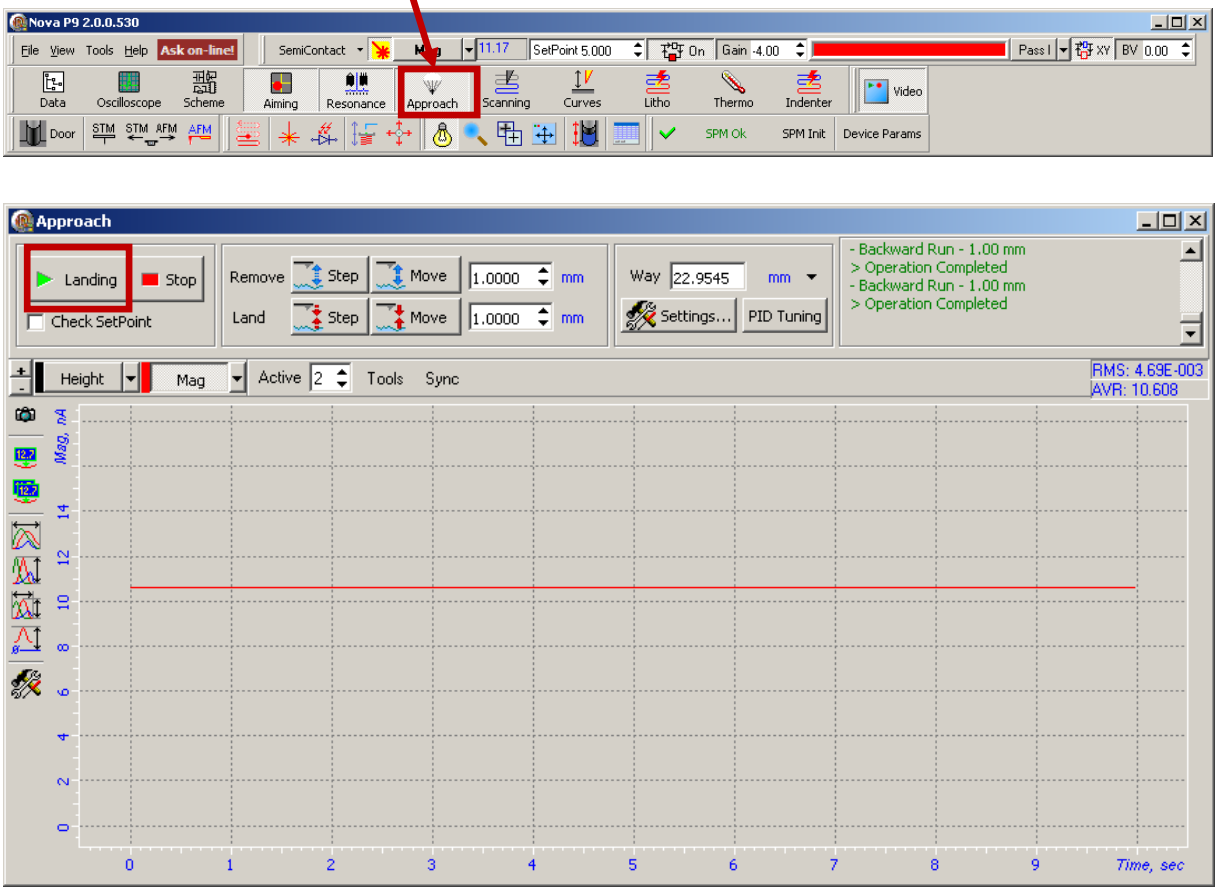


12. Activate FeedBack loop.

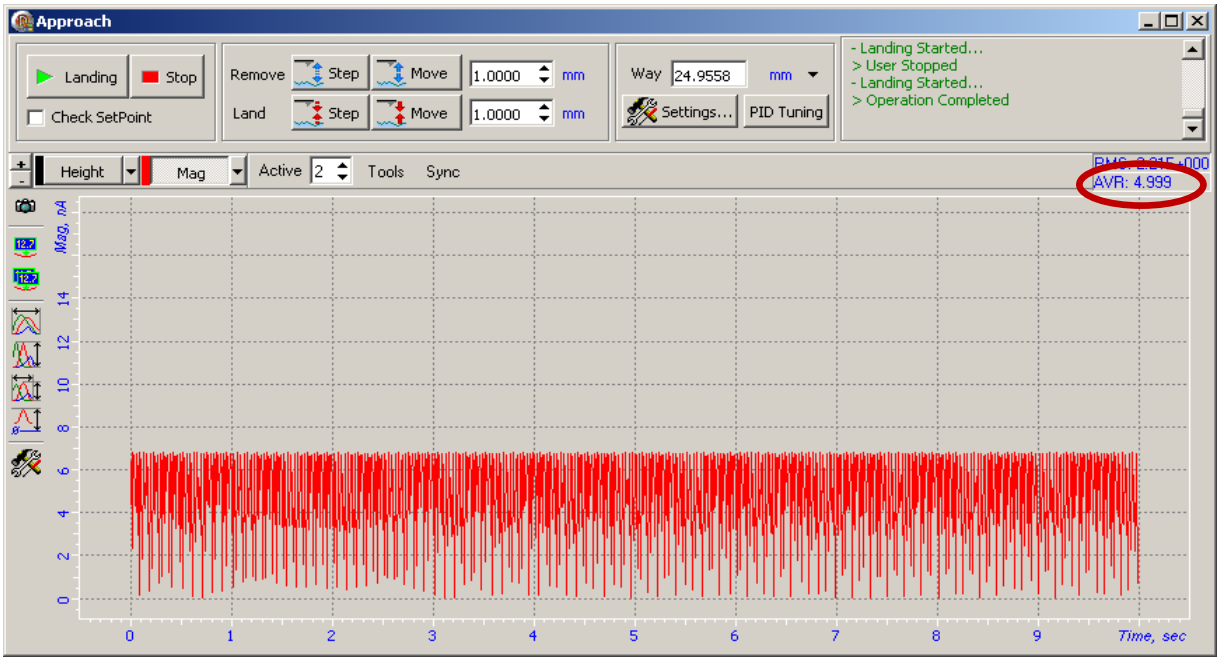


The fully red colored bar signalizes maximal protrusion of the scanner in **z** direction.

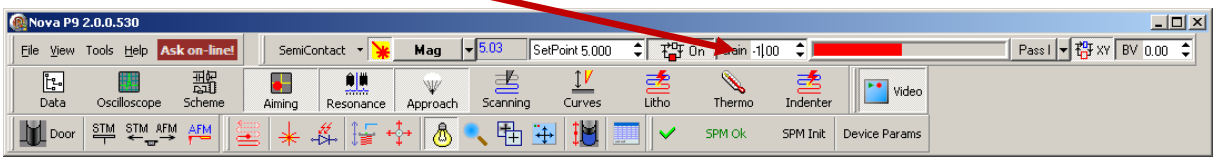
13. Using procedure ***Approach*** perform automatic landing of the tip to the sample surface with magnitude decay defined by **SetPoint**. Push the icon ***Landing*** and observe the run of the **Mag** signal.

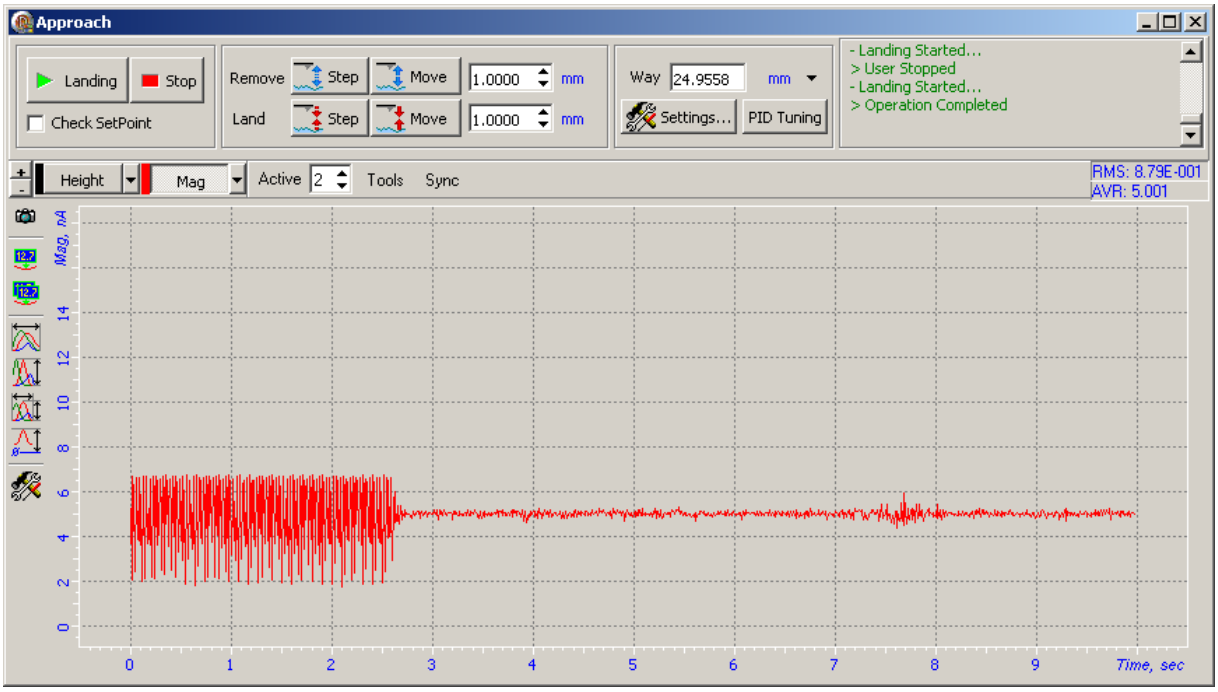


After the successful landing the value of Mag signal settles on the value given by the SetPoint.

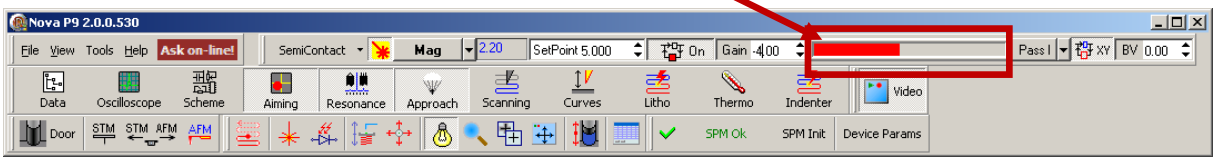


In certain cases the **Mag** signal shows strong noise. The noise disappears when lowering default value of the **Gain**.

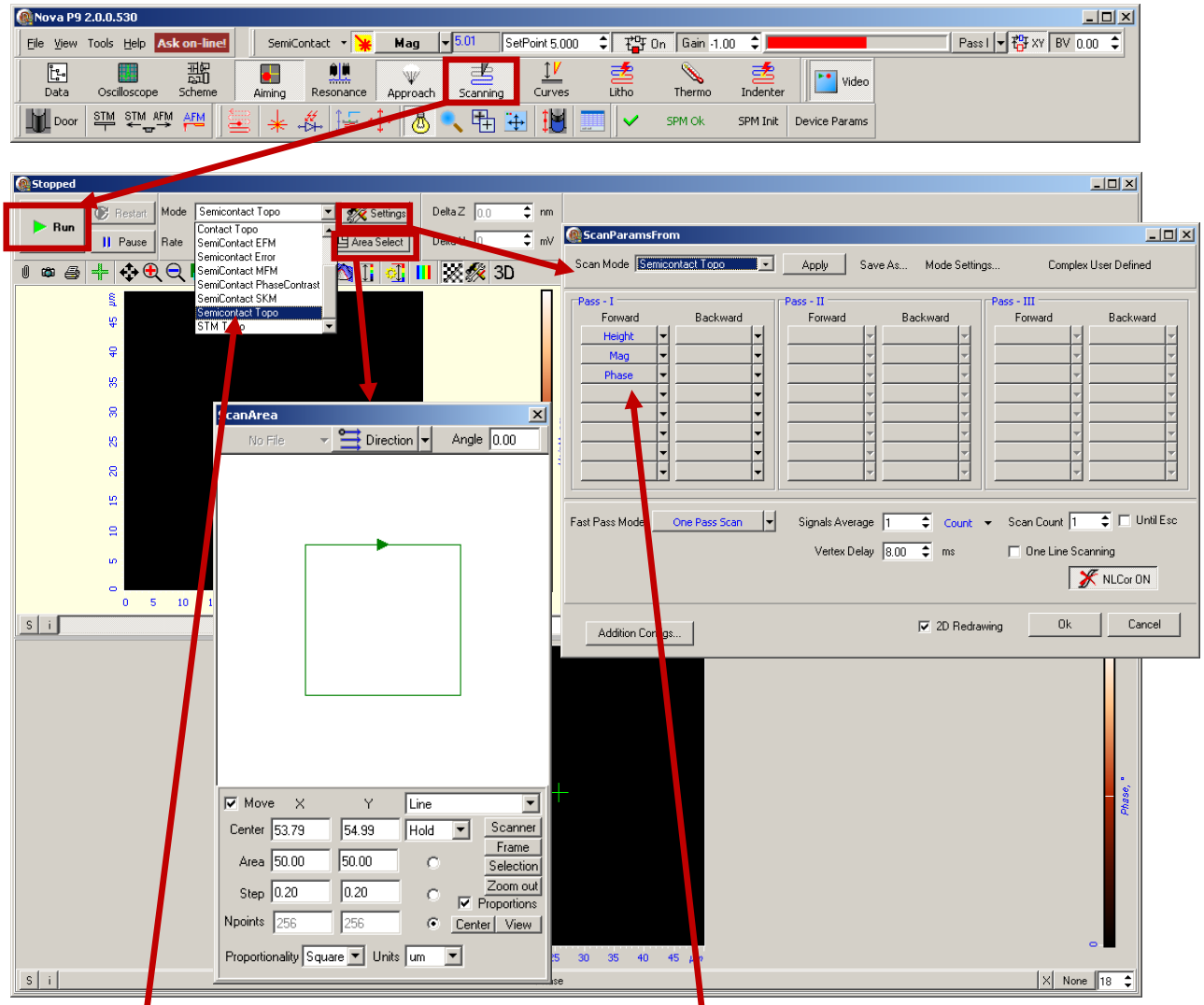




Landing is also signalized as a shortage of red bar signalizing protrusion of the scanner.



14. Pushing the icon ***Scanning*** initialize the window for the measurement.



Choose **SemiContact Topo** mode.

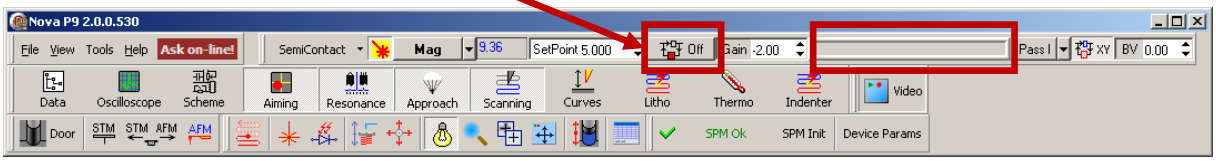
In menu Settings select following signals: „***Height***“, „***Mag***“, and „***Phase***“.

Choose the area going to be measured … menu “***AreaSelect***”, in the field “***Area***” enter initial sizes 50 x 50 µm. In the field “***Rate***” define the speed of the scanning, for the beginning choose 1Hz.

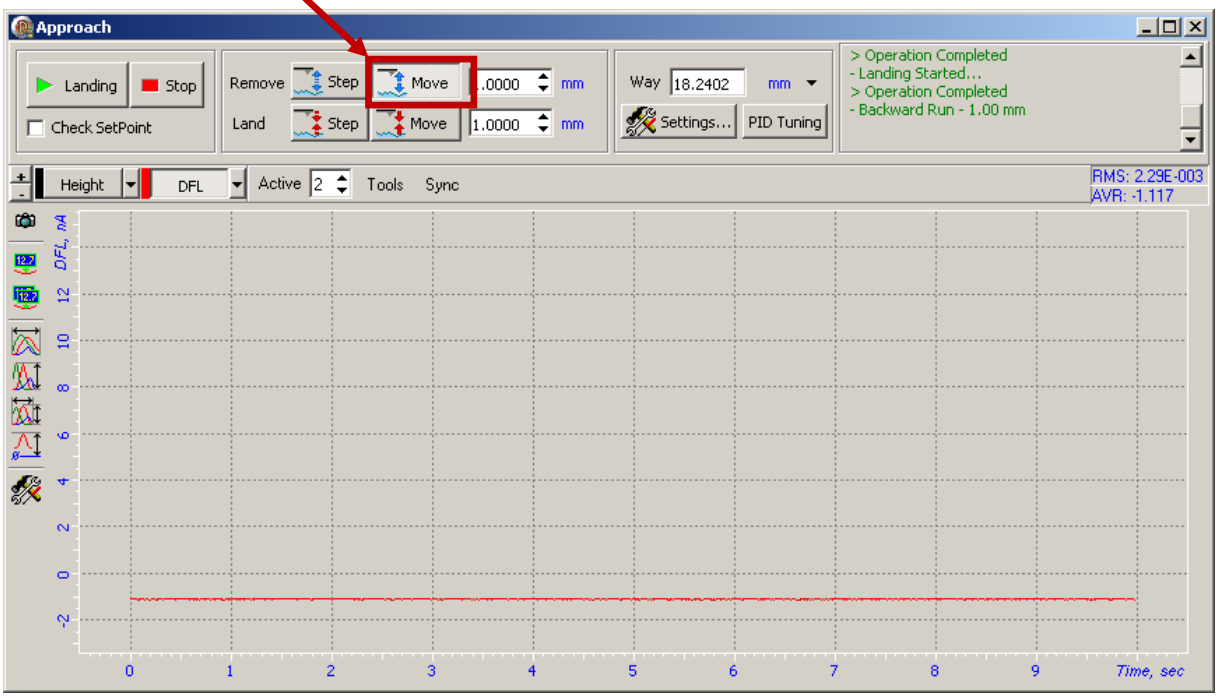
15. Now the measurement can be started, by pressing of the green button “***Run***”. Perform the measurement in three areas 50 x 50, 20 x 20 and 5 x 5 µm. With the aim to find optimal scanning parameters, change the parameters “**SetPoint**”, “**Gain**”**,** and “**Rate**”. In conclusion discuss how the changes of these parameters influence the quality of the images obtained. After the optimal parameters are found, perform scanning of entire area at these conditions.

16. After the measurement is finished save obtained images to the folder assigned with number of your group.

17. Switch off “FeedBack” loop.



18. Put back the tip from the surface (for the initialization of this window see paragraph 13).



Summary of results:

- evaluate the measured data using software Gwidion,
- analyze of the selected profiles. At the given profiles carry out the measurement of the periodically appeared parts of the surface and measure the heights of the typical parts,
- perform analysis for each magnification,
- present obtained results in well arranged table, including average values of the measured distances and heights,
- discus the differences occurred as a result of different magnifications,
- present surface topography in 3D images,
- discus the image registered in Phase contrast mode.