TUNING FIND SURFACE FOR PIUMA & CHIARO NANOINDENTERS

1. Find surface approach

The Piuma Nanoindenter features an automated find-surface approach, which allows a safe approach towards a sample or stiff surface for calibration when the sample-probe stiffness combination is matching. To check, please see our probe selection guide This approach uses a coarse-fine stepping routine, combining the motorized Z stage and the indentation piezo. The stepping of the motorized Z-stage can be confirmed by the 'beeping' sound, which is the sound of the motor moving. During find surface, the point of contact is determined by monitoring the bending of the cantilever while performing this routine. The Piuma or Chiaro software features a sensitive mode, which can be enabled or disabled (standard mode) (Figure 1). Each mode refers to a find surface threshold value which determines the triggering voltage corresponding to a certain amount of cantilever bending. It is recommended to start the experiment in sensitive mode. Nevertheless, it frequently happens that the surface is found too early when sensitive mode is enabled, possibly due to:

- Low cantilever stiffness used, such as 0.01 N/m or 0.05 N/m
- Low cantilever stiffness used in combination with a tip larger than 50µm, causing the cantilever to bounce during each find surface step
- Resonance of the cantilever with high ambient noise
- Accidental shake of the setup
- Adhesion forces or hydrodynamics above the sample surface

The mentioned circumstances can trigger the find surface approach too early (Chapter 2.1), therefore it is necessary to disable the sensitive mode in the advanced tab of the Piuma options in order to continue the experiment. One should note, that disabling the sensitive mode, means that the find surface procedure is now less sensitive. When approaching a soft sample, the find surface approach could possibly end up within the sample instead of a few micrometres above the sample surface. One could try to use a larger tip radius, which increases the contact area and therefore reduces locally the pressure. If that is not possible, the find surface threshold settings need to be tuned manually for the current probe – sample combination.

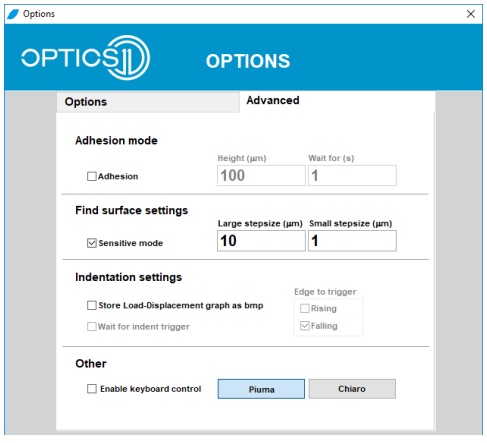

Figure 1: Options menu to select modes

2. Tuning the find surface threshold

The find surface threshold settings can be found in the 'Maintenance menu' of the Piuma software, which can be entered with the password 'showme'. One can choose to change the value for the standard (disabled sensitive mode) or sensitive mode when the current (default) settings for both modes don't yield a correct surface detection (Figure 2). The usual procedure is to increase or decrease the value in 0.01 steps and subsequently saving and trying out the new settings till the surface is being correctly detected.

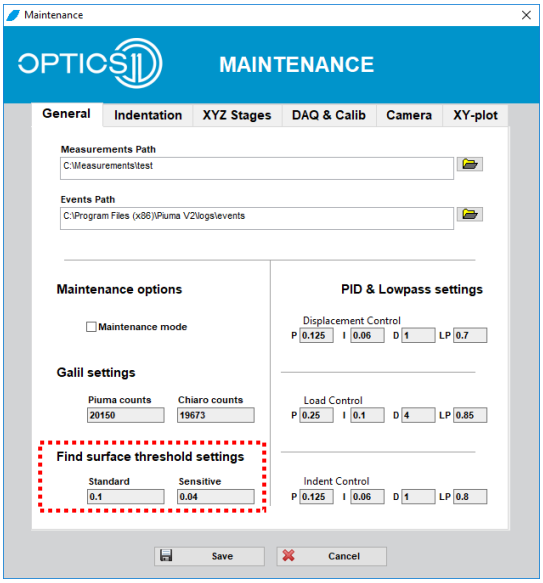

Figure 2: Maintenance menu with Find surface threshold settings

How to determine whether the find surface threshold is set too sensitive or too coarse?

- Surface found too early → too sensitive
- Surface found too late → too coarse

2.1 Correct find surface threshold

A correct find surface function can be live monitored by either closely watching the live monitor signal in the software (green line) or in the demodulation window of the OP1550 (with dot in red circle). The find surface procedure should stop just after the first contact with the sample surface, hence only one peak in the signal monitor window or only one shift of the white dot clockwise should be necessary to trigger the function to stop (Figure 3). To confirm, a default Displacement D-mode indentation can be performed to check if the measurement is being executed correctly from a certain distance above the surface, set prior in the Piuma software options (Figure 4).

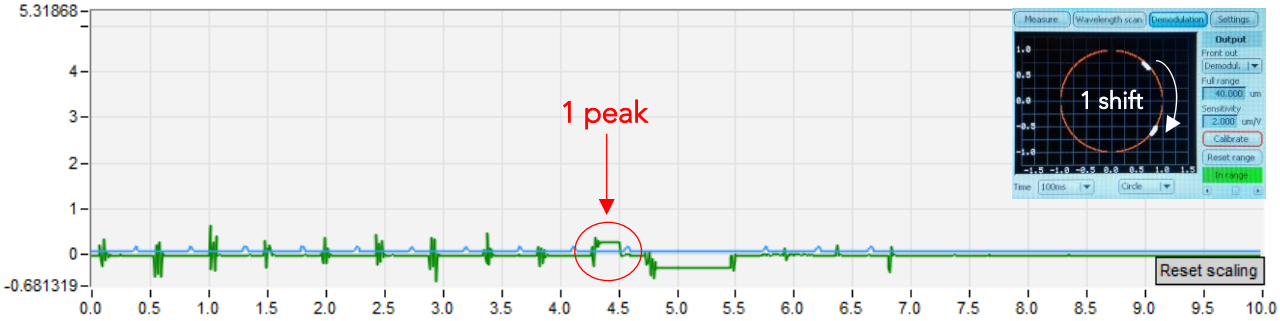

Figure 3: Live monitor signal in software: cantilever bending shown as green baseline, Piezo extension as blue line

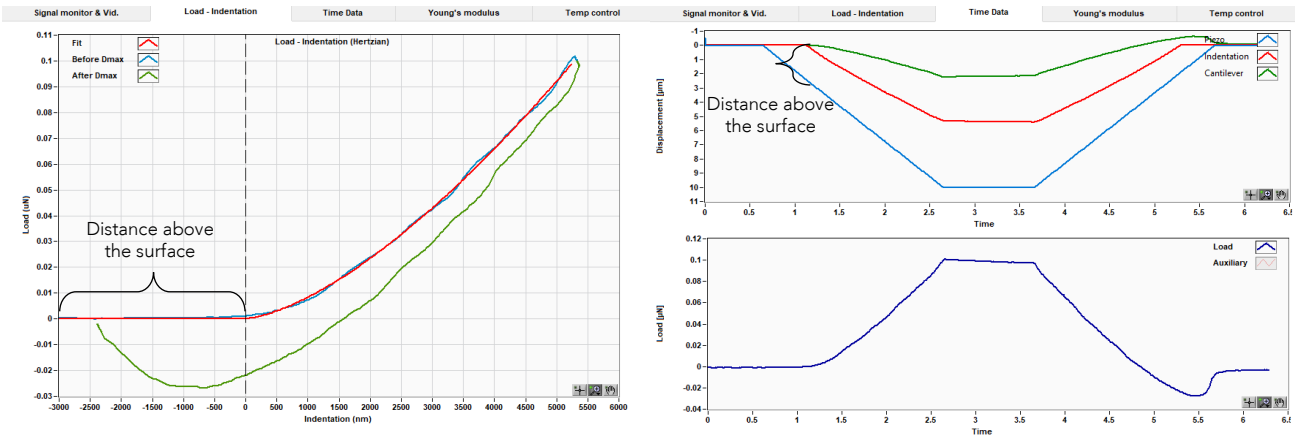

Figure 4: A correct load-displacement curve (left) and time data tab (right) after performing one indentation in D-mode from a certain distance above the sample surface.

2.2 Find surface threshold is too sensitive

When the threshold value is set too low, meaning that the sensitivity is too high, the find surface approach stops too early, as previously described. That happens usually after the first two initial steps when starting the find surface procedure either during calibration or sample approach (Figure 5). Nevertheless, this can also happen at later steps, close to the sample surface, triggered by e.g. adhesion forces or hydrodynamics above the surface pulling down the cantilever (Figure 6).

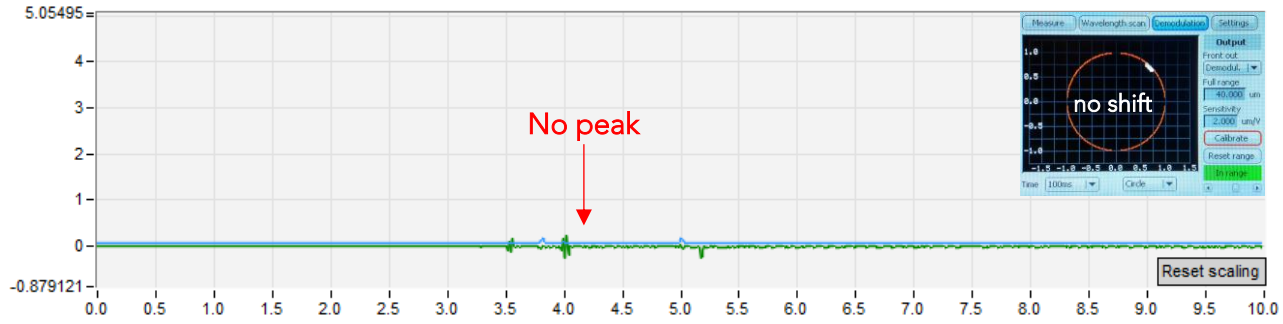

Figure 5: Live monitor signal: Find surface stops too early after initial steps.

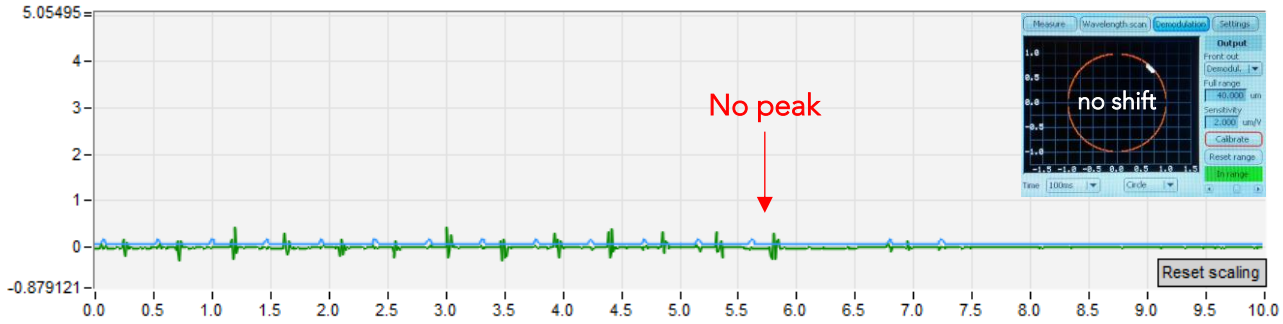

Figure 6: Live monitor signal: Find surface stops too early, close to the sample surface.

As in both displays no indication for a surface detection (no peak and shift) can be noticed, one can assume that the surface was found too early. This can be either confirmed by manually moving 10-15µm in Z-down direction and carefully monitoring the signal in the software and the OP1550, or by simply performing a default indentation in D-mode.

The resulting load-displacement tab in the software outputs a straight line with no-zero baseline, where the time data tab should show a flat green line, indicating that there is no cantilever bending, hence no contact to a surface (Figure 7).

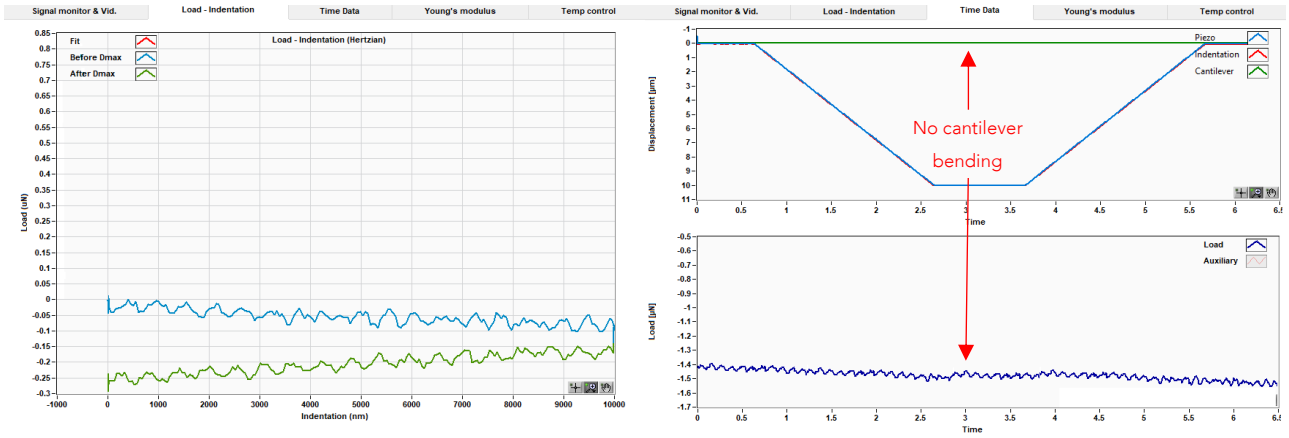

Figure 7: Load-displacement curve (left) and time data tab (right) after performing one indentation in D-mode, showing no cantilever bending, hence no surface detection.

This means that the find surface approach is too sensitive and the threshold value needs to be increased till the surface is being detected correctly, as described in Chapter 2.0.

2.2 Find surface threshold is too coarse

If the set threshold is too high, hence the sensitivity too low, the probe might stop within the sample and possibly destroy the cantilever. That's why it is important to keep the value as low as possible (not higher than 0.25). When monitoring the live signal and OP1550 signal and more than one peak or shift of the white dot is visible before the find surface procedure stops, the probe is already in contact a few steps before the procedure stops, hence too late (Figure 8). The required force, necessary to bend the cantilever to the extend, which corresponds to the set threshold, can only be generated when reaching deeper regions within the sample. This means that the approach is now not sensitive enough. This can be doublechecked with a default D-mode indentation, where the resulting load-indentation graph displays a no-zero-load - phase and hence no distance to the sample is present (Figure 9).

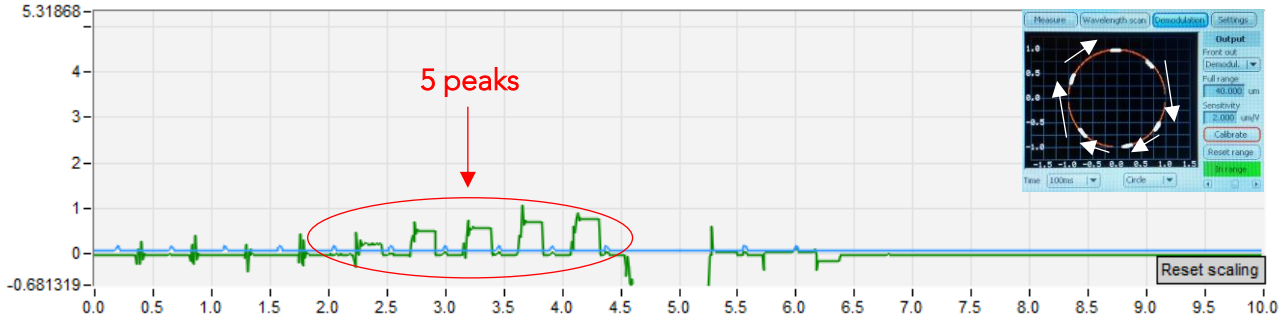

Figure 8: Live monitor signal: Find surface stops too late, already within the sample, indicated by five peaks (instead of one).

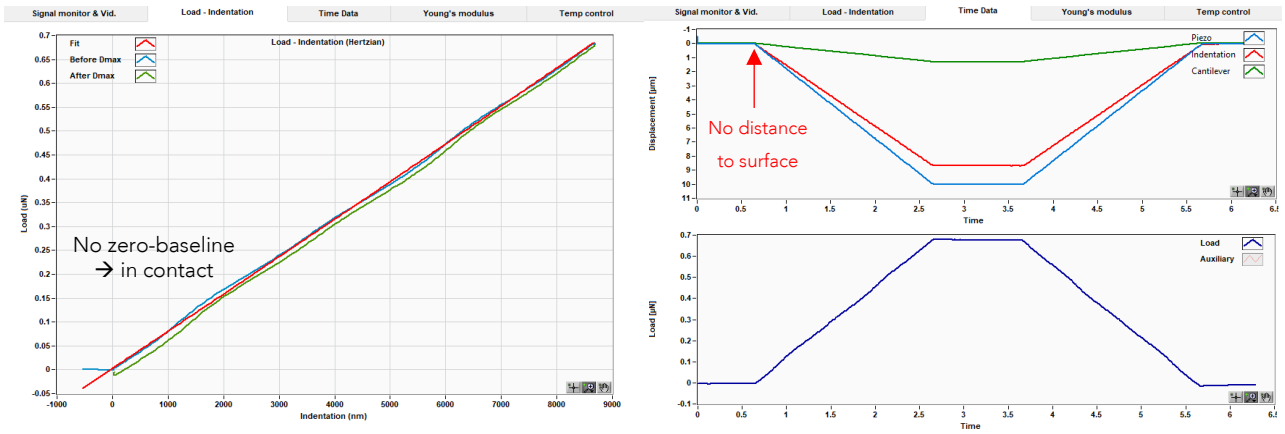

Figure 9: No Zero-baseline in Load-displacement curve (left) and no distance to surface shown time data tab (right), indicating that the measurement was performed when the probe was already in contact with the sample surface.

3. Flowchart on how to tune the find surface threshold correctly: