NIL Technology ApS
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Compact NanoImprint (CNI) Tool – CNI v3.0 Instruction manual

EC Declaration of Conformity for Machinery

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Herewith declares that "Compact Nanoimprint Tool" model "CNI v3.0"

- Conforms with the provisions of the machinery Directive (directive 98/37/EC) and with national implementing legislation
- Conforms with the provisions of the following other EC directives
  - Directive 2006/42/EC on machinery
  - Electromagnetic Compatibility (EMC), Directive 2004/108/EC
  - Low Voltage Directive (LVD), 2006/95/EC
  - Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment

Kgs. Lyngby, Denmark
2020-06-01

Brian Bilenberg, NILT Founder, Executive VP Mastering

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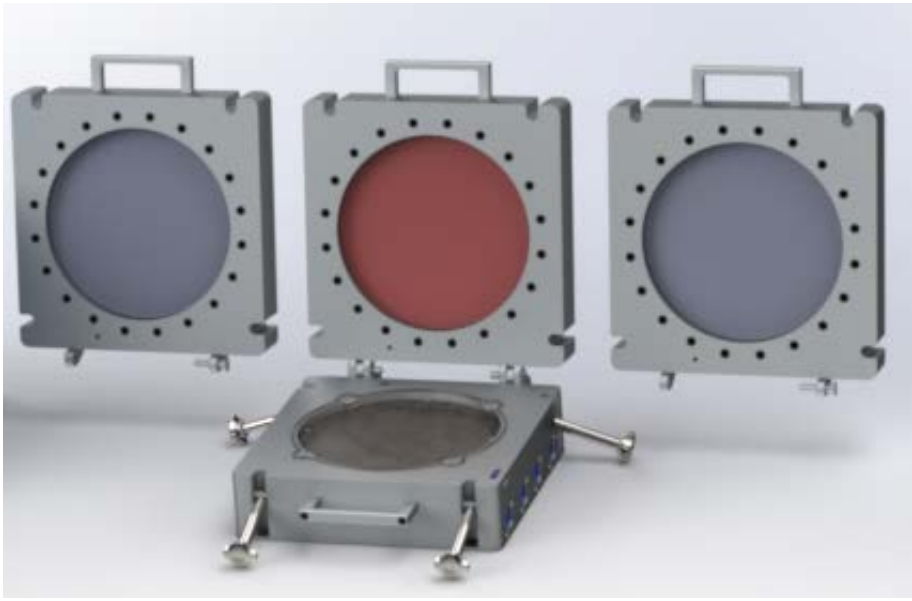
General description of the tool, the modules, and the options

The Compact NanoImprint Tool (CNI) performs thermal and UV nanoimprint lithography and hot embossing. The tool consists of a chamber (right), 2-3 modules (3 shown middle), a touch computer, and tubes and wiring. The chamber comes in a 210 mm version (shown below) and a 120 mm version (not shown) both have the same modules and lids available.

Three modules are available: the Control Module, the UV Module, and the High Temperature Heater module. The Control Module, including the chamber, is required. In addition, the user needs the UV Module or the High Temperature Heater module for UV or thermal nanoimprint applications, respectively.



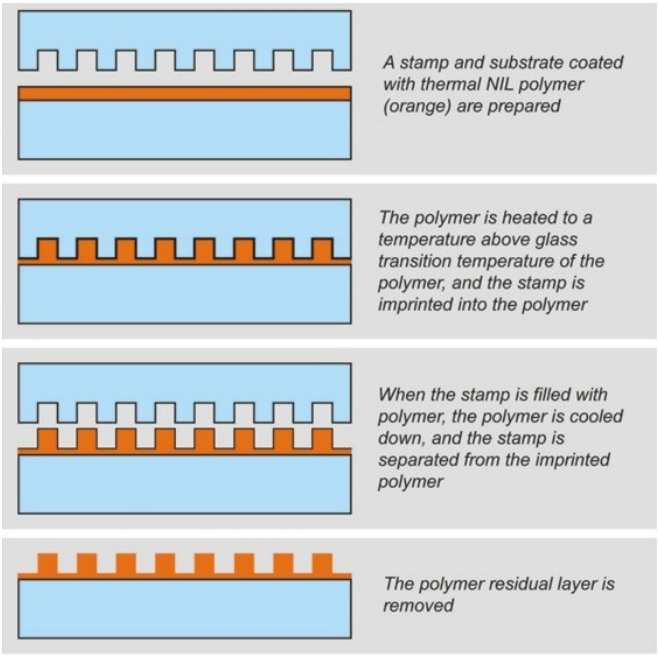
Three lids are available with each chamber. From left to right in the image above: UV365 nm lid with a built-in 365 nm UV source that can go up to 200°C. High Temperature Lid with no UV source that can go up to 250°C. UV405 nm lid with a built-in 405 nm UV source that can go up to 200°C.

The user controls the entire system from the touch computer. A separate user guide for the CNI tool control software is included in the package.

Nanoimprint in CNI

General thermal nanoimprint lithography process

In thermal nanoimprint, a thin thermo-plastic polymer layer is deposited onto a substrate and heated above its glass transition temperature (T_g). A stamp with predefined structures is pressed into the polymer forcing the polymer layer to adopt the inverse shape of the stamp. When the stamp has been sufficiently filled with polymer, the temperature is decreased below T_g, and the stamp and substrate are separated. The substrate now features an inverse replication of the stamp in polymer.



It is impossible to imprint all the way to the substrate surface; a thin residual layer will always be present. In cases where the polymer layer should be used as a mask for further processing, a residual layer etch is most often necessary. The residual layer etch is typically performed using an oxygen plasma and never takes place in the imprint tool itself.

Instructions for first use and operator training

Before using the system for the first time, users should read this manual as well as the software manual. Also, NILT provides instructional videos showing a hands-on tool setup as well as some examples of running basic recipes. These videos are not mandatory but should be viewed as supplementary and hopefully helpful material.

In some cases, the CNI Tool is delivered and set up by a NILT representative. In such cases, the representative will perform the necessary training of operators and engineers at the user's site.

The tool should never be operated without an active compressed air supply.

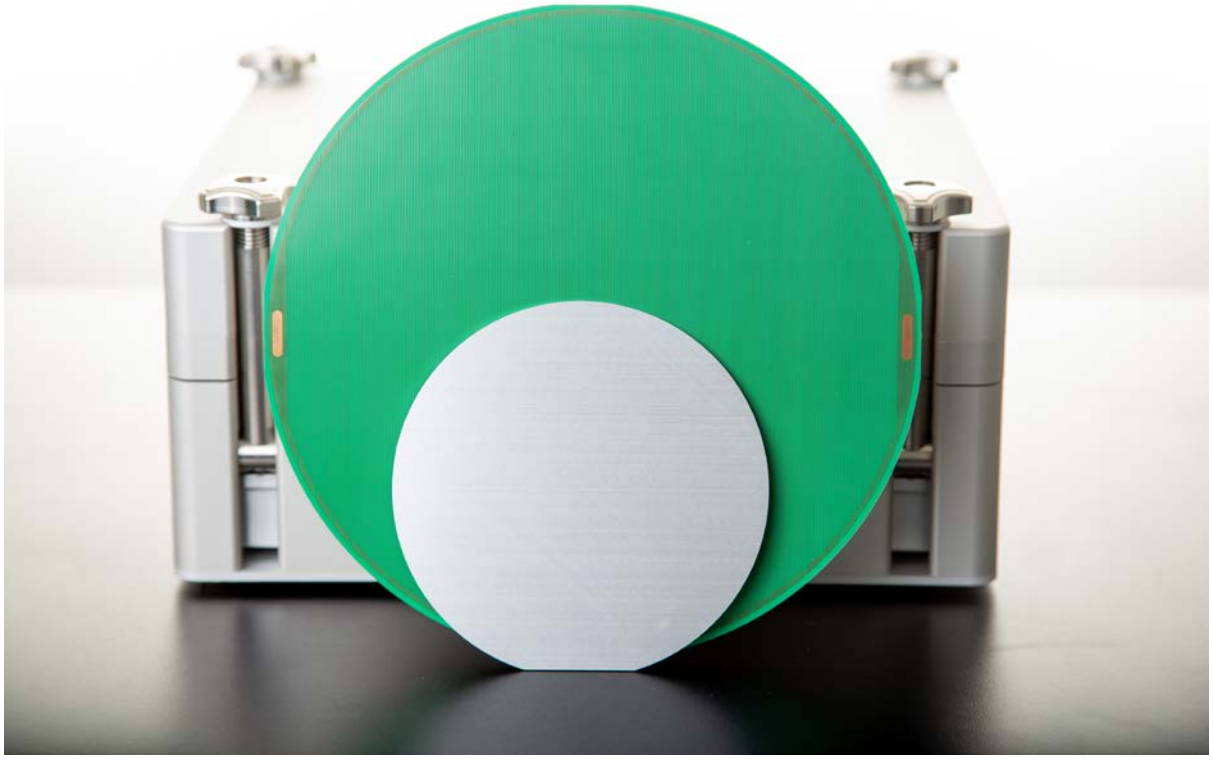
The main power switch is on the backside of the control module. However, powering down the computer, will turn off everything, except for one LED on the front of the tool that indicates that main power is still on. In daily use, it is sufficient to power down the computer, when the tool is not in use. If you are doing service or in case of failure, turn off the main power switch.

The Removable Heating Element (RHE)

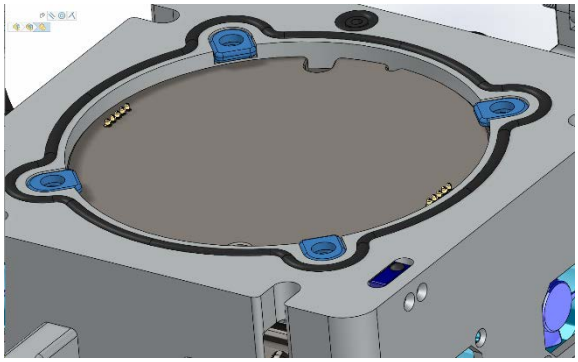
The CNI tool uses a removable heating element to control the temperature in the imprint stack. The Removable Heating Element features a metal grid with an electrical room temperature resistance in the range of 10-17 Ω. The metal grid increases the temperature of

the heating element by Joule heating. The temperature of the heating element is determined by measuring the electrical resistance of the metal grid and the included calibration file.

Here is the front and back of two removable heating elements, for 210 and 120 mm chambers.



On the backside you see electrical contacts. These contacts mate with spring loaded contacts in the CNI chamber (see image below)



When you install the heating element in your CNI, it is important that its contact area hits the spring-loaded contacts. The heating element is held in place in the CNI tool by four small holders highlighted in blue in the image above to the right. These holders are held in place by screws. These screws should only be tightened until you feel the first bit of resistance. There is no reason to tighten these hard.

Thermal nanoimprint in CNI

A CNI Removable Heating Element is used together with an imprint stamp in the tool

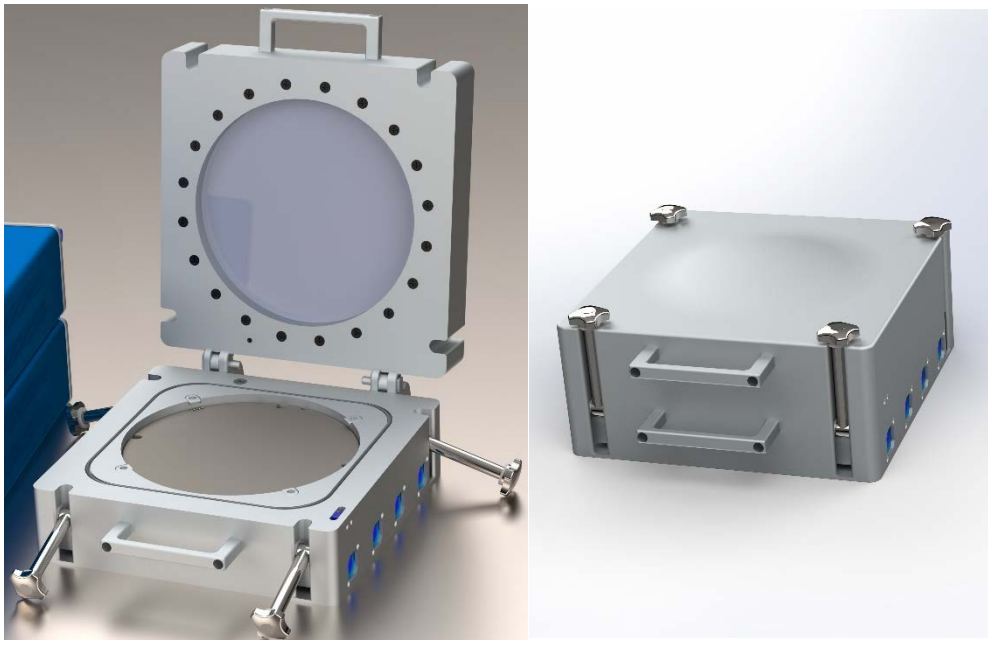
The RHE is placed in the chamber such that the spring-loaded contacts in the chamber contacts the contact surface on the heating element. The imprint substrate and the regular stamp are placed on top. The stamp features and the imprint polymer should be facing each other.

The user is free to choose whether the stamp or the imprint substrate should be closer to the heating element.

The imprint stack is of major importance in any imprint tool. In CNI, heating and temperature sensing is performed at the bottom of the stack, and that should be considered, when designing the stack. Here is a prioritized guideline for building your stack.

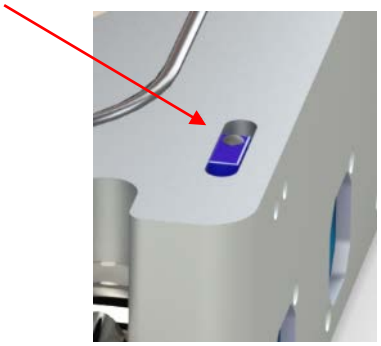
1. The CNI RHE must be at the bottom
2. If the stamp and substrate are of different sizes, the smaller part must be at the top
3. Avoid hard materials placed against other hard materials – if necessary, place a 0.1 µm thick Teflon sheet between the materials. For example; if you place a silicon regular stamp on top of your heating element, place a Teflon sheet between the two.
4. You should try to get the imprint polymer as close (thermally) as possible to the CNI RHE, since the temperature is best controlled near this part.

When you have finished loading the imprint stack, you need to close the chamber. Close the lid and tighten the screws.



We advise that you first tighten the screws in the back followed by the screws in the front.

The tool contains a safety contact embedded in the chamber

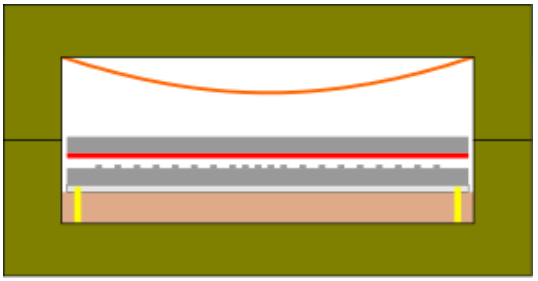
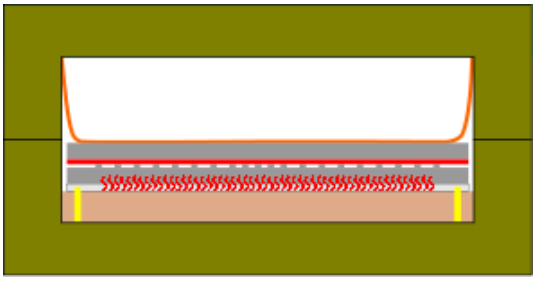


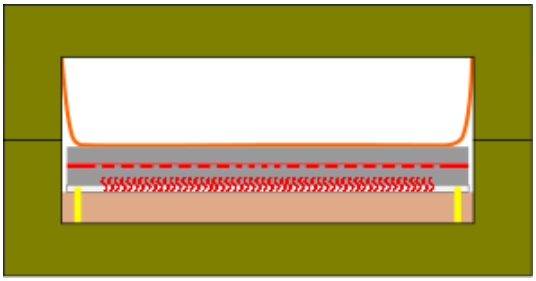
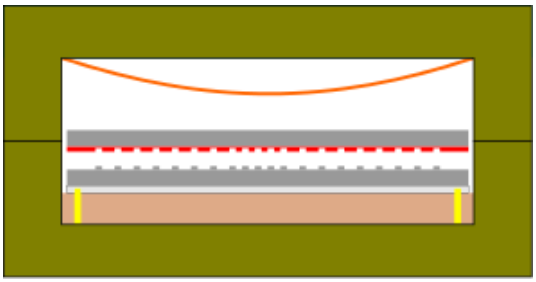
It is impossible to start an imprint process unless this contact is activated. The contact will be activated, when the chamber lid is closed and securely fastened.

If this contact is released at any time, i.e. the lid is opened, during the imprint process, all compressed air and vacuum will be released, and electrical heating and UV will be turned off immediately.

Warning!! Avoid blocking this contact with anything other than the chamber lid. This could lead to unexpected process start, which might release compressed air into the unrestrained membrane, as well as high intensity UV light in the room.

The imprint process is controlled by the laptop. A standard process consists of the following steps:

The heating element is placed at the bottom with the stamp on top. An imprint substrate with thin imprint resist (red) is placed on top of the regular stamp. The substrate is shown floating in air to emphasize that nothing is clamped together at this stage, but it is lying freely on top of the stamp. The chamber membrane (dark orange) is un-stretched and in its resting position.	
At the beginning of the imprint process, a small pressure is applied to the chamber membrane, such that it expands, and forces stamp and substrate into good thermal contact. Since the imprint temperature is not yet reached the stamp features have not yet begun to move into the imprint resist.	

When the imprint temperature is reached, a higher pressure is applied in the chamber membrane, and the stamp features move into the imprint resist. Temperature and pressure are held for the time set in the imprint software.	
After the imprint period the system cools to the desired release temperature (set in the imprint software), and then all pressure is released, and all electrical power is turned off.	

When the imprint process is finished, the bolts can be loosened, and the chamber opened.

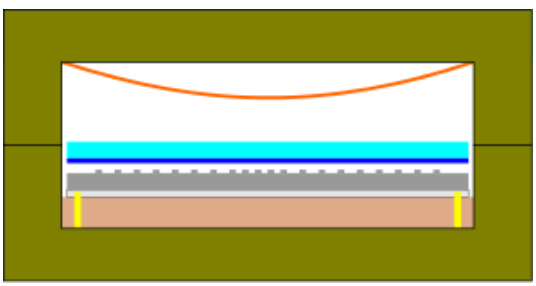
WARNING: Depending on the selected release temperature, the temperature inside the chamber may be as high as 250°C. Take all necessary precautions, when unloading the imprint stack.

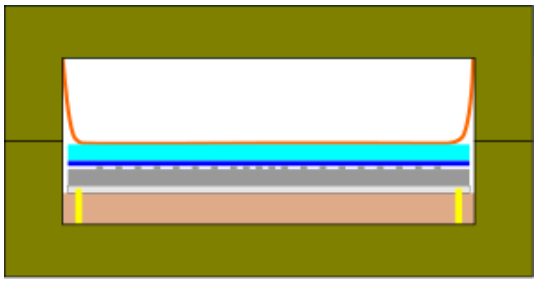
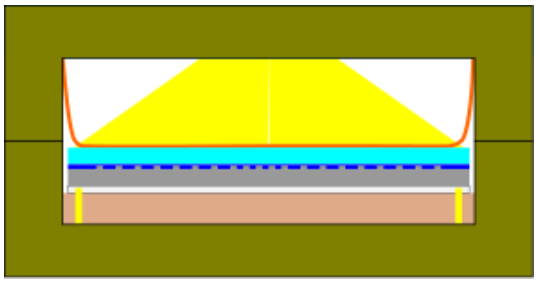
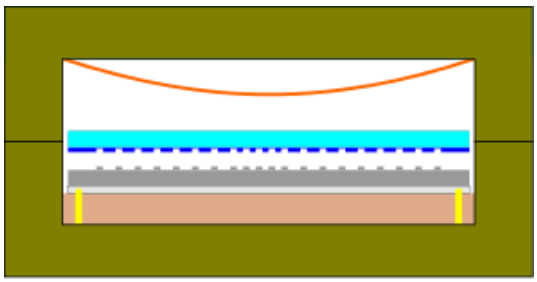
UV nanoimprint in CNI

UV nanoimprint has many similarities to thermal nanoimprint, so please read that section, even if you will only be doing UV imprinting.

Most UV resist flows with very little viscosity at room temperature, so the stamp is easily pressed into the polymer. In fact, gravity and surface tension will most often be enough to fill the stamp cavities with resist. When the stamp has sunk fully into the polymer, the resist is exposed to UV light, which cures and hardens the resist. The stamp can then be removed. In UV nanoimprint either stamp or substrate must be UV-transparent. In the following, we will assume, the substrate is transparent. The transparent part must be on top facing the UV source in the lid.

In CNI it looks like this

The RHE is placed at the bottom with the stamp on top. A transparent imprint substrate (cyan) with thin UV imprint resist (blue) is placed on top of the regular stamp. The substrate is shown floating in air to emphasize that nothing is clamped together at this stage, but it is lying freely on top of the stamp. The chamber membrane (dark orange) is un-stretched and in its resting position.	

At the beginning of the imprint process, the software-controlled pressure is applied to the chamber membrane, such that it expands and forces substrate and stamp into intimate contact, and the imprint resist fills the stamp cavities.	
When the stamp cavities are filled with resist, the UV source in the chamber turns on and cures the resist for the time set in the software, while the pressure is maintained.	
After the imprint curing time all pressure is released, and stamp and substrate can be separated.	

When the imprint process is finished, the chamber can be opened.

UV nanoimprint at elevated temperature

Some UV nanoimprint resist are solid at room temperature and require heating to become moldable. In these cases, one first heats the polymer to the desired temperature and then cures the polymer with UV.

CNI can also do this by combining the thermal and UV steps described above.

Using vacuum in CNI

In some cases, both with UV and thermal nanoimprint, it can be advantageous to have vacuum in the imprint chamber during the imprint process. All vacuum operations are handled by the control module and the laptop. Most often, one would evacuate the imprint chamber prior to the process, but you can do it at any time in the CNI.

When you have vacuum in the chamber during the process, you will not be able to open the chamber immediately after the imprint. You must wait for the chamber vacuum to be released. The speed of the vacuum release is controlled by the vacuum release valve. A quick release might cause water vapor to form inside the tubing resulting in a slow pumping time for the next run. A slow release is … slow.

Protective measures

Provided the CNI is operated according to this manual and any supplemental NILT advice, no specific protective measures or precautions are foreseen. However, users of the CNI should use their best judgement regarding personal protective equipment and other health and safety measures that their specific working environment might require.

Instructions in case of accident or failure

In case of failure, turn off the main switch on the backside of the control module, or remove the wall plug from its socket. This will power off all heating and UV light and bring the chambers back to ambient pressure.

Instruction for setup and connections for the machine

The CNI chamber, modules, and touchscreen should be placed on horizontal surfaces. The modules may be put out of the way, since they are completely controlled from the laptop except for the master on/off switch. The touchscreen and tool should be placed such that manual operation of the two can be performed in a comfortable and ergonomically safe way, e.g. on a table.

Connections: All connections should be made before powering up any part of the system. Below, all system connections are indicated and listed. All necessary cables are supplied with the system. The list below assumes that you have all modules. If you only have some of the modules/options, just omit the connections that do not apply.

1. Mains power connection. The tool must have connection to ground. This also contains the tool's main on/off button and the fuse drawer.
2. Mains power thru – Connect to power input on another module (Heater or UV)
3. USB input – Connect to the touchscreen to this input via a USB cable.
4. USB hub used to connect to the other modules (19) with standard USB cables
5. Connect to vacuum gauge using a standard VGA cable.
6. Heat to chamber. Output from the heater module (through the control module) to the chamber. Connect to (20) on the chamber using the supplied cable.
7. UV to chamber. Output from the UV module to the chamber. Connect to (24) on the chamber using the supplied cable.
8. Control Module to Heater Module communication. Connect to (18) on the Heater Module using the supplied cable.
9. Control Module to UV Module Communication. Connect to (18) on the UV module using the supplied cable.

10. Control Module to Chamber Communication. Connect to (23) on the chamber using the supplied cable.
11. Vacuum release. This needle valve controls the rate at which the imprint chamber vacuum is released at the end of the process. Higher rates will result in water condensation on the chamber and tubing walls resulting in prolonged pump down times during next use.
12. 10 mm outer diameter push-in connector for the vacuum connection from the vacuum pump.
13. 10 mm outer diameter push-in connector for the vacuum connection to the chamber's vacuum connector (21).
14. 6 mm outer diameter push-in connector for the compressed dry air supply.
15. 6 mm outer diameter push-in connector for the compressed dry air connection to the chamber's compressed air connector (22).
16. Mains power for the Heater/UV module. Connect to (2) on the control module or (17) on the other Heater/UV module
17. Mains power thru to feed the (optional) other Heater/UV module. Connect to (16) on the other module.
18. Control module communication. Connect to (8) or (9) on the control module.
19. USB in. Connect to the USB hub (4) on the control module.
20. Heat in on the chamber. Connect to (6) on the control module.
21. Vacuum to imprint chamber. Connect to (13) on the control module.
22. Compressed air connection to the chamber. Connect to (15) on the control module.
23. Chamber to Control Module communication. Connect to (10)
24. UV power to chamber. Connect to (7)

Great care has been taken such that it should be not possible to make any wrong electrical connections, as no cable will fit, where it is not supposed to go.

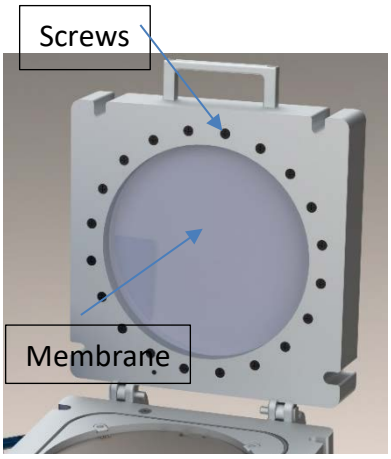
It is, however, possible to connect compressed air and vacuum wrong, so please take care and make sure that you connect the lab supply to (12) and (14). (13) and (21) should be connected. Also, (15) and (22) should be connected.

No special precautions are needed to avoid noise and vibrations.

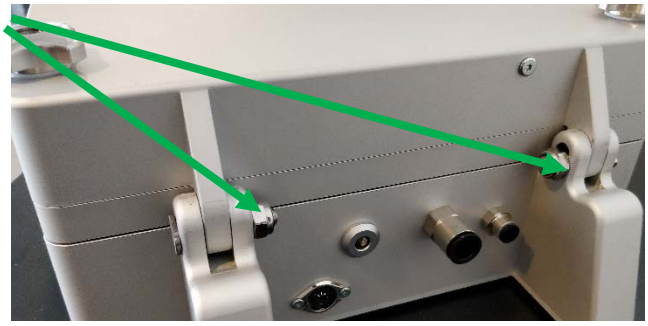
Description of user adjustment and maintenance

The tool must be powered off during maintenance.

User maintenance is limited to



- Cleaning the inside of the chamber – this is done by wiping it down with an ethanol-soaked tissue.
- Cleaning the membrane – this is done by wiping it down with an ethanol-soaked tissue.
- Tightening of screws in the chamber top in case the membrane should start to leak.
- Membrane replacement in case of membrane failure. This is done by first separating the lid from the base and put the lid safely on a table. Then, removing the screws, replacing the membrane (supplied by NILT) and replacing the screws.
- Exchange or unmounting of lid. When the chamber is opened, the lid is only attached to the based by two screws and bolts in the back. The bolts are only loosely tightened (finger tight), as they are not part of the mechanical stability during imprint. When you remove the two bolts, the lid comes off easily, and you can attach another lid.



If you have any doubts about tool maintenance, do not hesitate to contact NIL Technology. We will guide you.

CNI spare parts

There are a few items in the CNI tool that are prone to wear out or break if not handled properly. These include the CNI lid membranes, and the removable heating elements.

Below, you find a list of available spare parts. Choose the ones you need and contact us for a quotation.

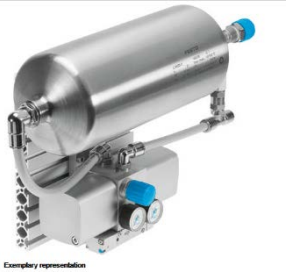
- NILT51101 - RHE (Removable Heating Element) Type A (for CNIv3.0-120 mm)
- NILT51102 - RHE Type B (for CNI v3.0-210 mm)
- NILT52101 - CNIv3.0-120 HT membrane (set of 3)
- NILT52102 - CNIv3.0-120 UV membrane (set of 3) For both UV365 and UV405 lids
- NILT52103 - CNIv3.0-210 UV membrane (set of 3) For both UV365 and UV405 lids
- NILT52104 - CNIv3.0-210 HT membrane (set of 3)

CNI consumables

These are items used in the imprinting process. They will be consumed or wear out fairly quickly. We can help you, if you need more. We stock the following consumables. Contact us for a quotation.

- NILT54101 - Teflon sheets 100 mm round, 100 µm thick (10 pcs)
- NILT54102 - Teflon sheets 120 mm round, 100 µm thick (10 pcs)
- NILT54103 - Teflon sheets 210 mm round, 100 µm thick (10 pcs)
- NILT54001 - Topas 8007 sheets A4 size (10 pcs)
- NILT54002 - Topas 8007 sheets 100 mm round, 140 µm thick (10 pcs)

Description of tools that can be attached to the machine



The CNI tool works up to 10 bar pressure. However, most labs have only 4-8 bar in their compressed air wall supply. In these cases, it can be advantageous to attach a pressure booster between the wall supply and the control module compressed air input.

We recommend this model FESTO DPA-40-16-CRVZS2. You can buy direct from FESTO or buy through NILT.

Disassembly when out of use or predictable machine failure

A NILT engineer should be consulted before attempting or performing any repair. In case one of the modules fails, NILT shall be contacted and decision about repair or replacement will be made.

Instructions for transportation and/or shipping

When the tool is moved over short distances, it should be disconnected and hand carried. The tool should be packed in protective boxes for longer transports. Check during unpacking that no parts of the system were bent or damaged while being transported.

Information of airborne noise emission

Noise emission from the tool is limited to the noise from the fans. These are rated below 50 dB(A).

Instruction for equipment disposal

The tool should be disposed according to local regulations dictating the proper disposal of electronic equipment.