Leica
MICROSYSTEMS

Leica EM ACE600
Operating Manual

167202032 Version 04/17

Important Note

Leica Mikrosysteme GmbH reserves the right to change technical specifications as well as manufacturing processes without prior notice. Only in this way is it possible to continuously improve the technology and manufacturing techniques used to provide our customers with excellent products.

Issued by:

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Hernalser Hauptstrasse 219
A-1170 Vienna

Table of Contents

1. Introduction

In order to ensure the safety of operators and service technicians, and to prevent any damage to the Leica EM ACE600, it is essential to read this manual carefully before beginning to work with the system.

This user manual is intended to provide the user a complete understanding of the system (including its specified limits and capabilitites), as well as to maintain and service it in accordance with its physical parameters.

This user manual includes important information regarding proper and economical installation, operation, servicing, troubleshooting and repair. Following these instructions will help prevent hazards, reduce repair and downtime costs, and prolong the system's service life.

In this user manual, symbols are used to alert the user about important information, such as necessary safety precautions, activites relating the operation and/or maintenance of the system, and relevant process-oriented descriptions or remarks.

Symbols used in this manual and their meaning:

Danger!

Instructions regarding possible hazards are identified with this symbol. **Ignoring these alerts may result in serious injury!** Users of the instrument must comply with instructions at all times.

Caution!

This symbol alerts the user to important information that may endanger staff or result in damage to the system if it is ignored.

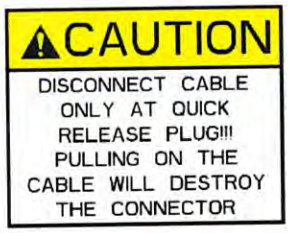
Lifting hazard. Single person lift could cause injury. Use assistance when moving or lifting the coater.

Note!

This symbol indicates further information relating to a previous explanation, which does not have a safety-critical function. However, it is important to follow this information to ensure that the system functions optimally.

Wear clean, powder-free gloves.

Symbols and indications on the instrument and their meaning:



The plug is equipped with a locking mechanism. Please do not pull on the cable! Grasp the knurled part of the plug and retract for disconnecting the cable.

Hazardous Voltage! Enclosed Voltage or current hazard is sufficient to cause shock, burn or death. Disconnect and lockout power before servicing.

Danger of pinching the fingers when closing the flange (stage).

Hot surface during and right after processing the sample. Allow to cool before servicing the ion source.

Warning! Improper use of the instrument can cause serious harm. Read the manual before operating the system.

Port to connect a <= 16GB USB memory stick for data up and download.

This product has been tested to the requirements of CAN/CSA C22.2 No. 61010-1, second edition, including Amendment 1, or a later version of the same standard incorporating the same level of testing requirements.

1.1 Identification

1.1.1 Product

Leica EM ACE600 High Vacuum Coater

1.1.2 Name and address of the manufacturer

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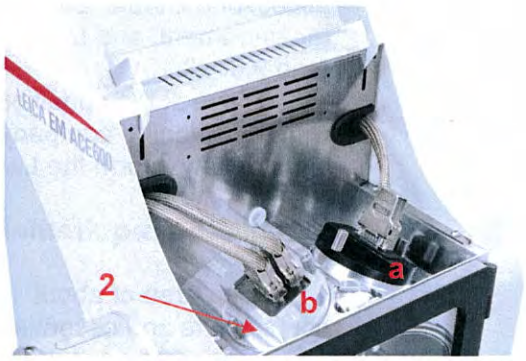
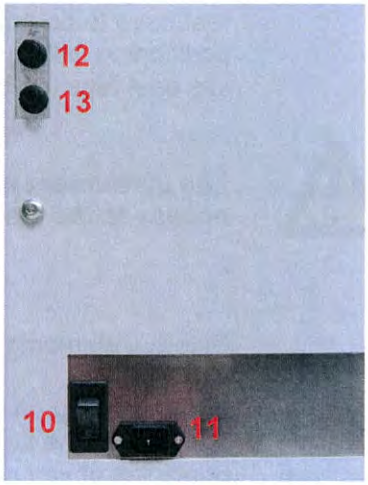
Hernalser Hauptstraße 219
A-1170 Vienna

Tel.: +43 1 488 99-0
Fax: +43 1 488 99-350

Internet: www.leica-microsystems.com

3.2. Instrument overview





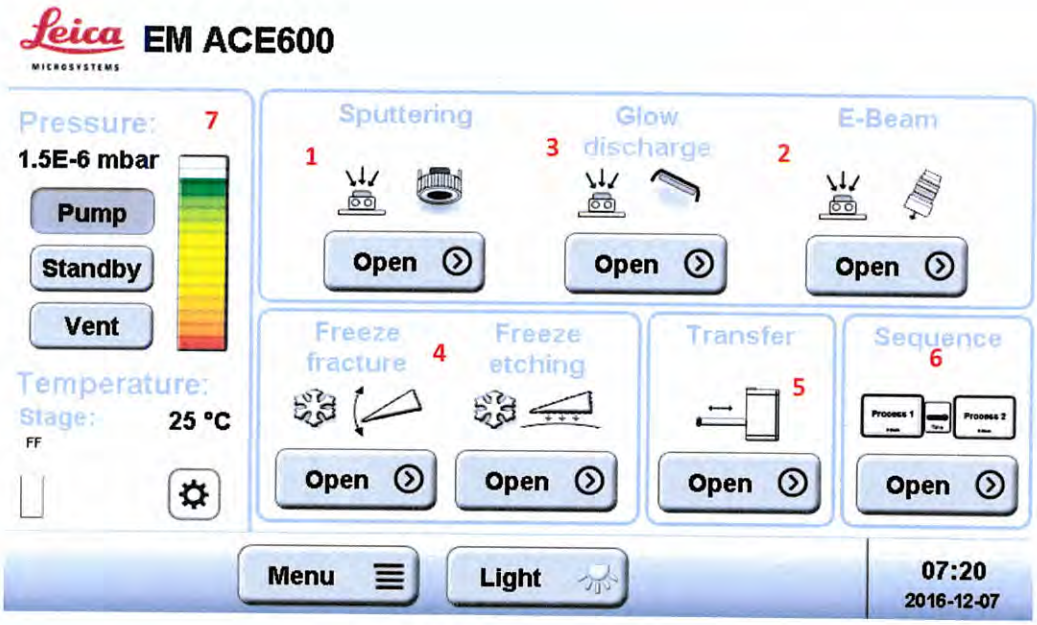
1. Source cover
2. Source head (sputter (a) or carbon thread (b))
3. Shutter
4. Chamber
5. Sample stage
6. Touch sensitive control panel
7. Adjustable feet
8. Chamber door
9. USB port
10. Power supply switch
11. Mains power inlet for coater
12. Argon gas inlet
13. Nitrogen gas inlet

4. Operating instructions

Touch screen control panel
The LCD control panel is used for communicating with the Leica EM ACE600 coating system as well as for data input and output. The parameters for the coating process are edited via the touch screen.
For operating the screen, a touch screen pen can be useful. For calibrating the screen, a touch screen pen should be used.

Sharp pointers may damage the touch screen.

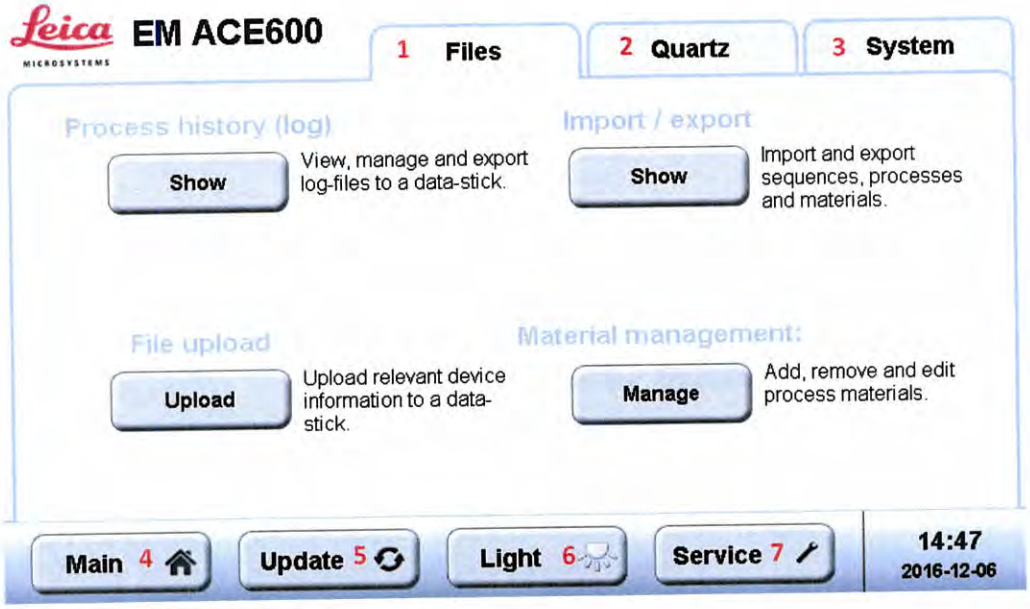
As an example, the main screen of a highly equipped instrument is shown with sputtering (1), e-beam evaporation (2), glow discharge (3) and a cryo stage (4). In addition, there is a transfer system available (5). Single processes can be put into sequence (6). On the left-hand side of the touch screen panel there is always an overview of the pumping and vacuum status shown as well as the temperatures of the stage when available (7).



The software can be updated by the user using a USB stick. During the update the instrument must not be switched off otherwise, the system may not function.

4.1 General functions

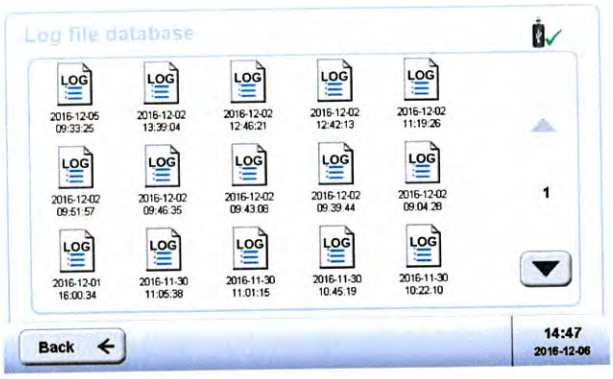
Push menu on the first screen after switching on the instrument to access files (1), check the quartz crystal (2) and adjust system settings (3).



Main (4) always brings you back to the first screen with the overview of available processes. Update (5) is used when a software update is performed. The light button (6) operates the chamber light and the Service button (7) gives access to the service environment asking for a password. This area is reserved for Leica authorized personnel.

Log files can be downloaded or deleted and protocols can be uploaded. Connect a USB stick to the port on the touch screen panel and select

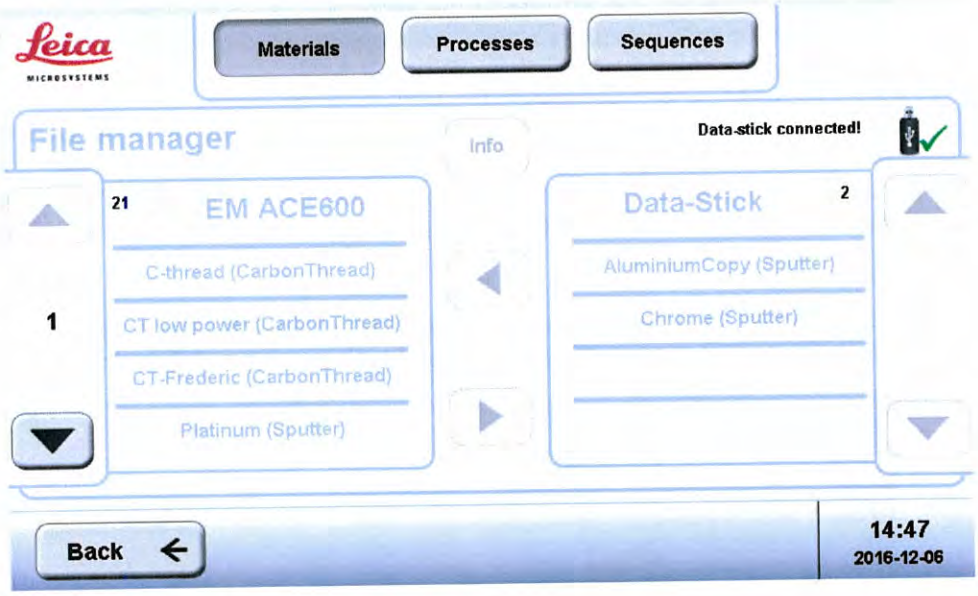
Shows all the log files. They can be selected by tapping on them and exported to a USB stick.



Import / export

Show Import and export sequences, processes and materials.

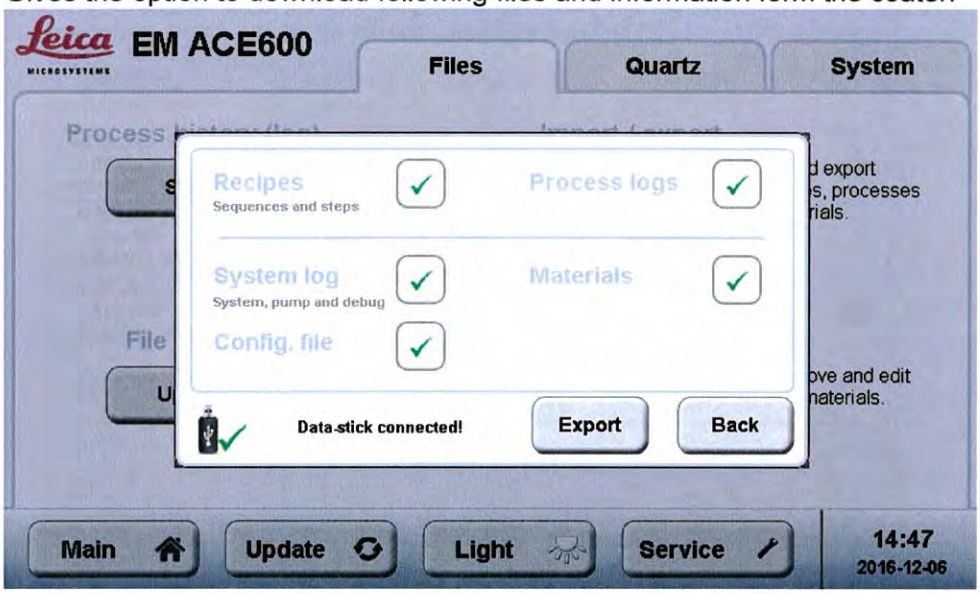
All stored processes can be exported onto a USB stick and be imported back to the instrument from a USB stick.



File upload

Upload Upload relevant device information to a data-stick.

Gives the option to download following files and information form the coater:

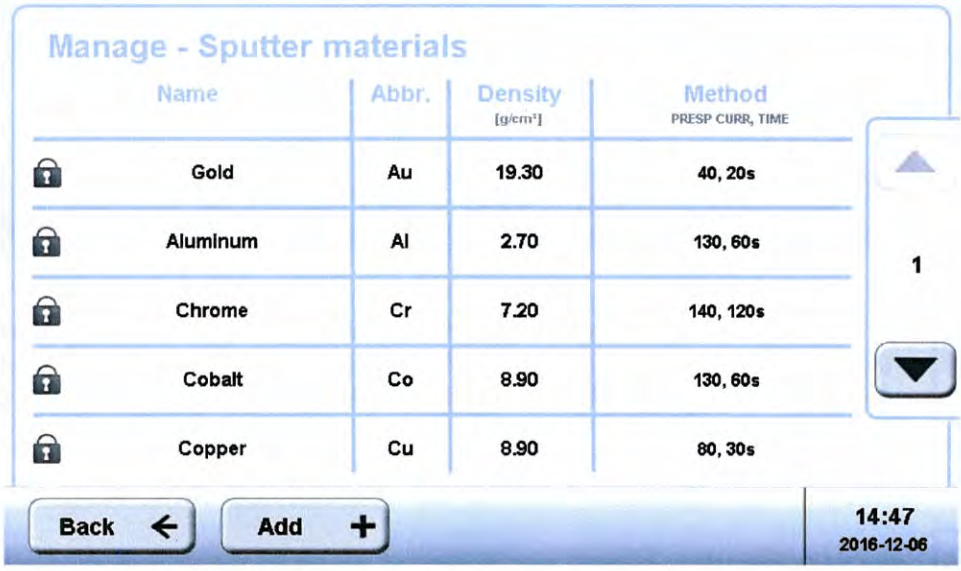


Material management:

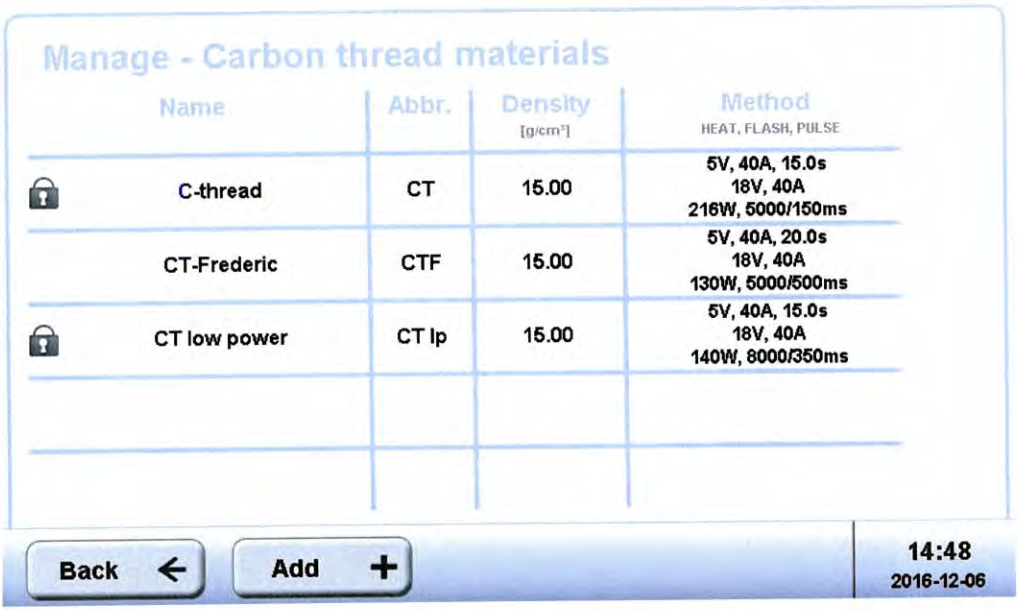
Add, remove and edit process materials.

Gives the option to create new materials for the different coating processes.

Example sputter materials: Add a new material and fill in the required data (specific weight and settings for pre-sputtering). Tap on a line for copying or editing the material. The pre-set materials are locked, only new ones can be edited.



Example carbon thread material settings. Add a new material and fill in the required data (specific weight of carbon and the parameters for pulsing or flashing method). Tap on a line for copying or editing the material. The pre-set material is locked, only new ones can be edited.

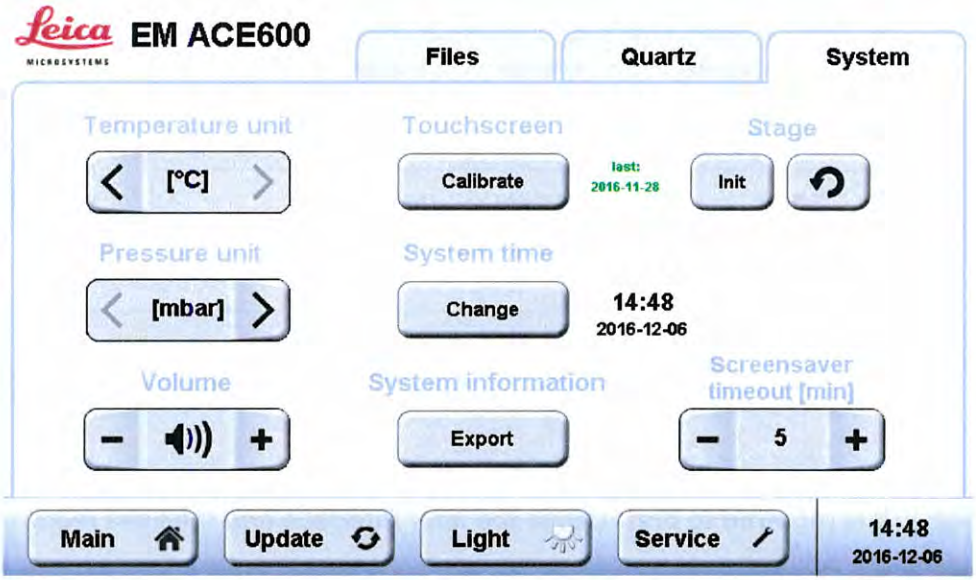


The instrument can test the frequency of the quartz.

A new quartz has a frequency of 6 MHz and can be used until it shows unstable in the quartz test. E.g.: 1 nm carbon is reflected in about 15 Hz reduction, 1 nm of platinum refers to around 145 Hz.

If a side quartz is used it has to be set accordingly on this screen, otherwise the thickness calculation is wrong.

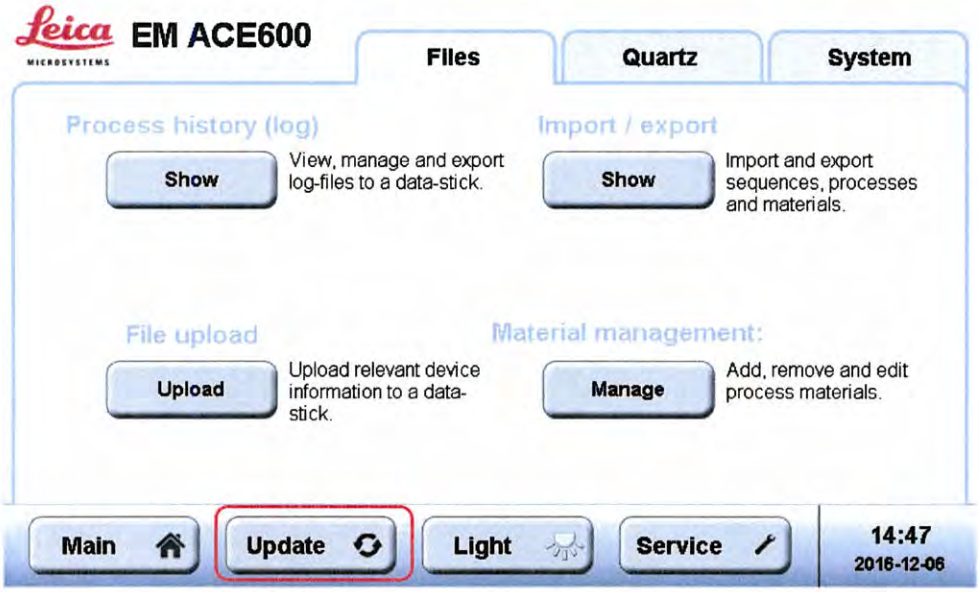
Under System, parameters, such as units, time, and volume of the instrument can be adjusted. Using the Export button, all relevant instrument information can be saved into a USB Stick. Additionaly, the stage can be set to its initial position.



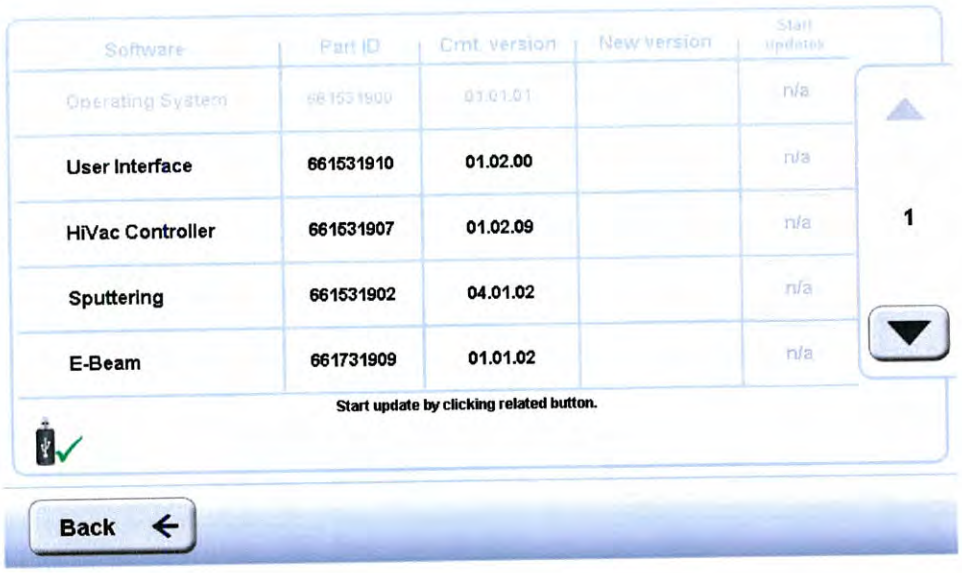
The coater is delivered calibrated. If the touch seems to lose its accuracy, calibrate the screen.

4.1.2 Software update

Enter the menu, connect a USB stick to the port on the touch screen panel and press update.



Choose from the list which updates shall be performed by pushing the respective button on the select update column.



It is required to first update the user interface and then the required controllers.

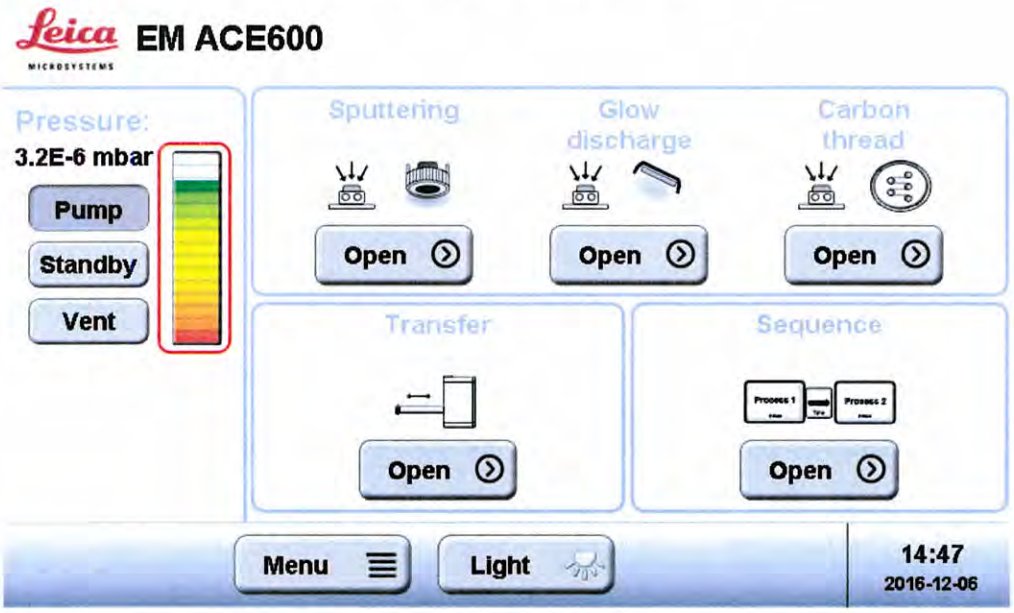
The update files need to be on a USB-stick in a folder with the directory Leica/CTupdate.

4.2 Pump and Vent

The system can be pumped down at any time. It can be vented at any time when a process is not running. In addition, there is the option to set the turbo pump into the standby mode. This is recommended when the instrument is kept running for a longer period to keep good vacuum. The pressure bar indicates the pumping and venting progress.
If the door is not closed, the pumping cycle will not start and an error message will appear. A time-out message shows if there is a leak when pumping down (e.g. the source is not placed correctly, or the chamber door is not closed).

Time can be saved by starting the pump as soon as the sample is placed in the chamber otherwise pumping will start only when a process run is started. Also the sputter process can be speed up when the turbo pump is already in standby (faster adjusting of the sputter vacuum).

The vacuum level is visualised using the vacuum bar.



On most screens there is a vacuum bar element included to quickly read the vacuum level.

4.3 Vacuum test

After connecting the coater as described in 3.5, the coater can be tested for vacuum.

Switch on the instrument on the rear by pushing the mains switch down and push the Pump button.

If the vacuum does not reach 100 mbar in 5 min, a vacuum leak is present and needs to be eliminated.

4.4 Process start and stop

The coating process can be started at any time (system evacuated or not) if the door and source cover are closed and the source is connected (electronic safety switches prohibit starting with open door or source cover).

The Start button will turn into a Stop button when the system starts the coating cycle.

Once the "Start" button is activated, the coater will automatically run the complete coating cycle. At the end of the process the system eithers stays under vacuum or vents automatically (vent after process is activated, defined within the process parameters).
Pressing the "Stop" button will terminate the process (after confirmation) regardless of the step of the process. The system either stays under vacuum or vents automatically (vent after process is activated, defined within the process parameters)

4.5 Thickness monitoring and geometrical correction (QSG)

A quartz crystal swings in a certain frequency. Coated with a material, this frequency reduces according to the material and the applied thickness. With this information, the accurate film thickness coated during a process run can be determined.
Every Leica EM ACE600 system is equipped with the QSG film thickness measurement monitor. The user can choose between termination by QSG and

termination by timer. Even when terminating by timer, if the quartz is installed the layer thickness is displayed in the summary of a finished process.
The quartz crystal is positioned in the middle of the table of the stage. The tooling factor to correct a height difference of the sample surface of a large sample to the quartz is calculated automatically. According to the selected metal or carbon thread, the parameters set are used to calculate the layer thickness.

4.6 Carbon thread coating

The carbon coating process is carried out by evaporating a carbon thread. It is possible to coat using short pulses of 150 milliseconds (standard, this can be defined in the material file of the carbon thread) or evaporating the thread completely with maximum power, a so-called flash.

Pulse mode
When using the pulse mode, the process can be terminated according to the desired coating thickness or a set number of pulses.

Flash mode
When using the flash mode, the process is terminated after the selected number of carbon thread sections has been evaporated. The resulting thickness is shown in the process summary.

For best results and fault free operation, only the Leica carbon thread should be used (16771511116).

To minimize carbon fiber residues dropping onto the sample we recommend using the "Pulse" mode rather than the "Flash" mode.

After choosing and starting a protocol the system will perform the following steps automatically.

- Pumping starts
- Pumping until base vacuum is reached
- Checking the availability of at least one carbon thread section, otherwise the process stops after delivering an error message

Checking threads <u>after reaching vacuum</u> is necessary because the threads are heated slightly for measuring. When the vacuum is too low, there is a risk of oxidation.

- When reaching base vacuum, outgassing (pre-heating) of the first available thread for 15 seconds (time can be set in editing of material, see 3.14)
- Opening the shutter and starting rotation (if activated)

Step-wise rotation should be used for the evaporation, only then a homogeneous distribution can be ensured.

- Pulsing to the desired thickness or pulsing/flashing the requested number of pulses/sections. Each section required to fulfil the set protocol is outgassed separately before use.
- Closing the shutter
- Displaying the results of the process (thickness, number of pulses / flashes)
- Venting or staying in vacuum

4.6.1 Loading a carbon thread

The carbon thread can be loaded as a single thread or as a double thread. Thin layers from 1 to at least 20 nm can be achieved (there is variance in threads).

To minimize carbon thread waste, when loading a double thread, cut a piece of thread twice as long as the width of the black door frames of the coater. Fold the thread into half and load it.

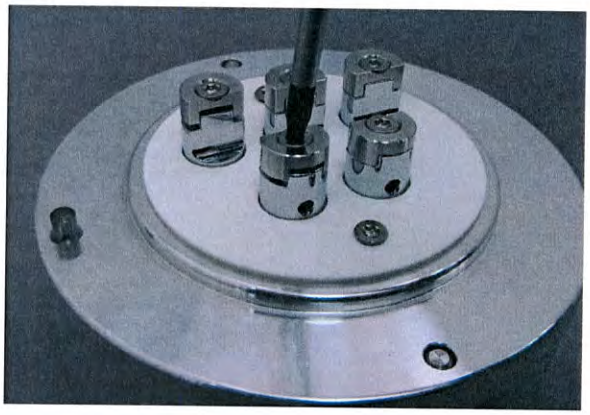
Make sure the instrument is vented (see 3.2).

- Open the source cover (1)
- Unplug the connectors (2)
- Unscrew the 2 evaporation head screws to remove the flange (3)

Prepare the following parts on a clean desk:

- Carbon head (1)
- Torx TX 10 (2)
- Brush (3)
- Carbon thread (4)

Loosen all 5 clamp screws with the Torx key.

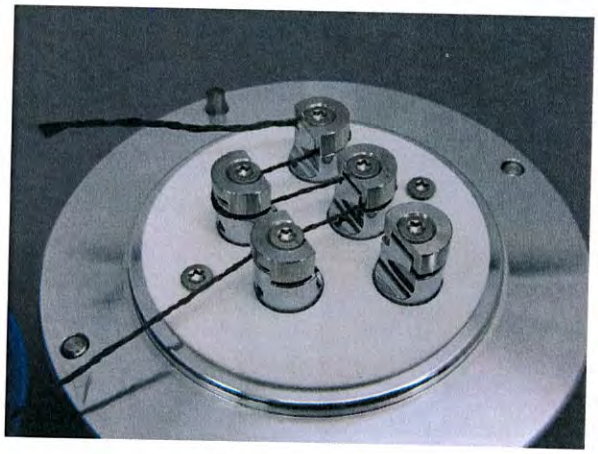


Remove any carbon thread residue using the brush supplied.

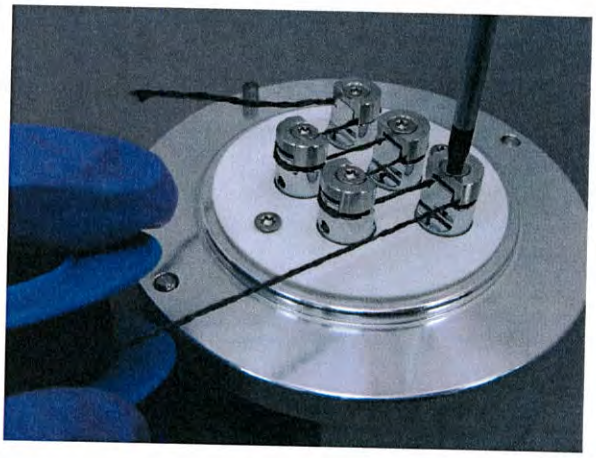
Do not brush off the threads close to the instrument. Use a bin well a side and placed on the floor. This avoids fibers to reach the inside of the instrument.

Loop the carbon thread around the first clamp and pull both ends gently to the left.
At the same time tighten the screw as shown in the picture.

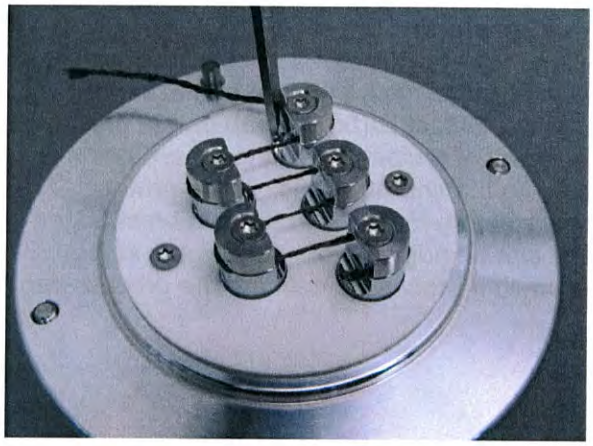
Wind the thread around the other clamps.
Take care that the thread slides into the clamping groove (1), follow the path:



Pull the thread gently and tighten the last clamp.



Tighten the remaining 3 screws and trim thread on both ends.



If not all screws are tightened the instrument may not recognize the thread section.

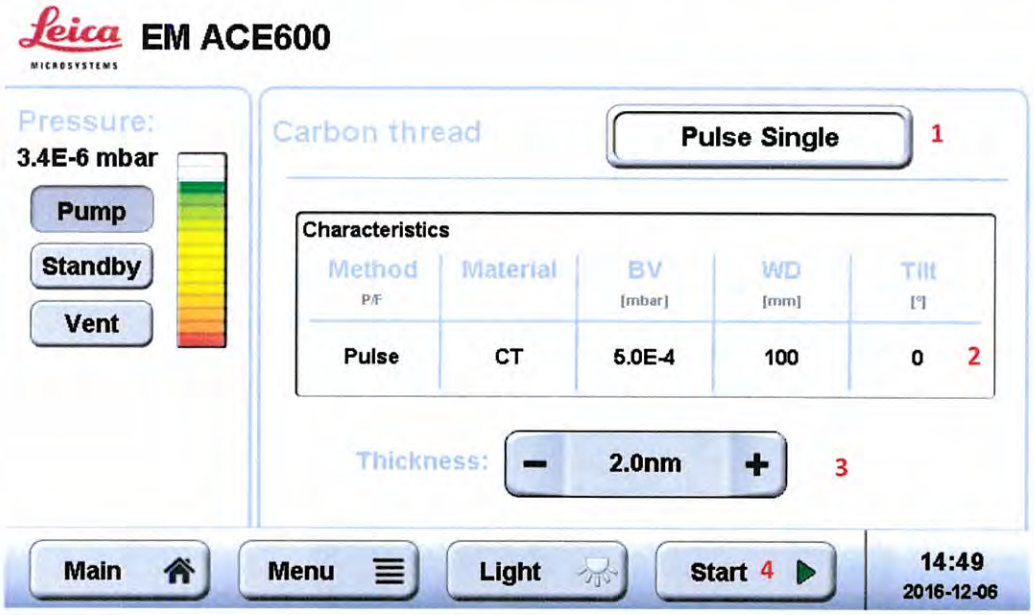
Clean the sealing surface with a lint-free tissue.

There is a Leica EM ACE600 YouTube video where the loading of the thread can be seen: http://www.youtube.com/watch?v=Qj3Y-WfNbvM

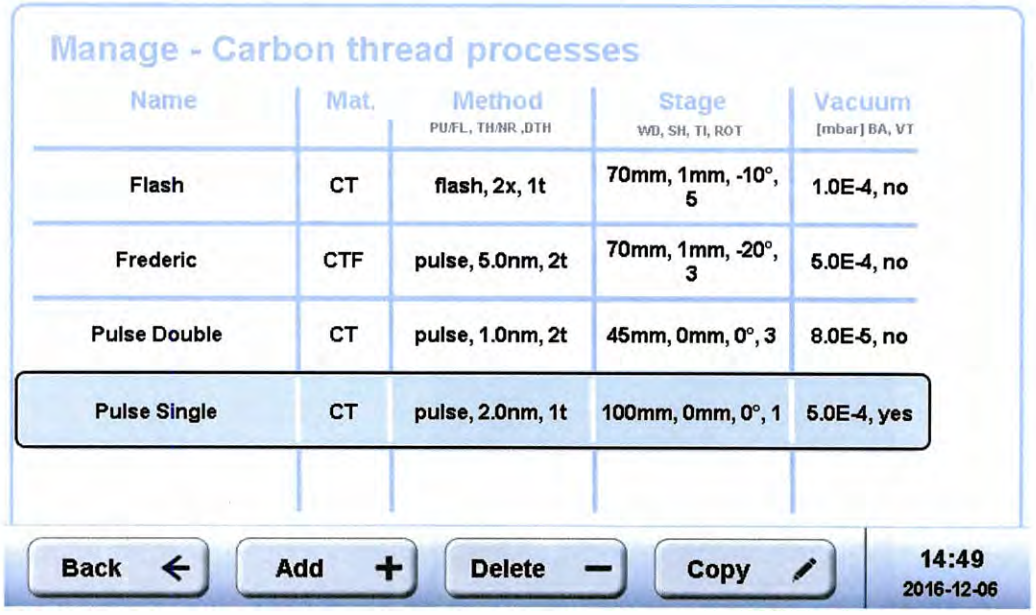
After the carbon thread is loaded, replace the head, gently tighten the fastening screws and connect the cables and close the cover.

4.6.2 Choosing a carbon thread protocol

When the head is inserted after completing the preparation in 4.6.1 an evaporation process can be run. Select carbon thread on the first screen to enter the process screen. In the library of recipes (1) all stored protocols are available and can be chosen. Tapping on the characteristics of the protocol (2), opens the list of recipes. There, the parameters for the process can be changed and saved. Thickness or pulses/flashes can be adjusted on the process screen (3). Once everything relevant for the coating process is defined, the process can be started (4).

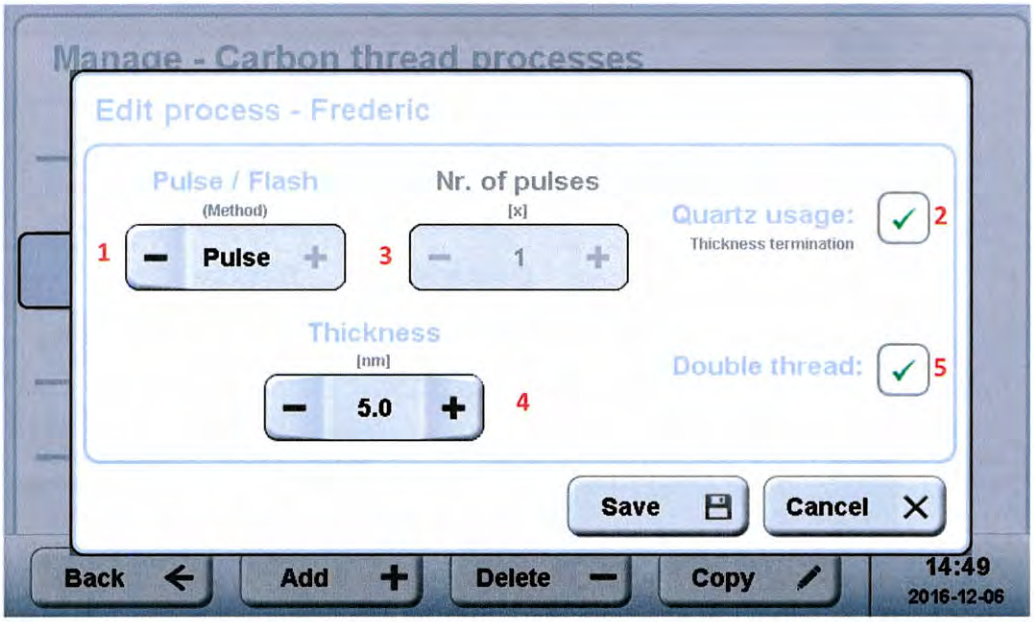


Select a protocol by tapping on it. Once it is marked, by tapping on a specific category, the parameters can be changed. Alternatively, a protocol can be copied and then modified or a new one added.

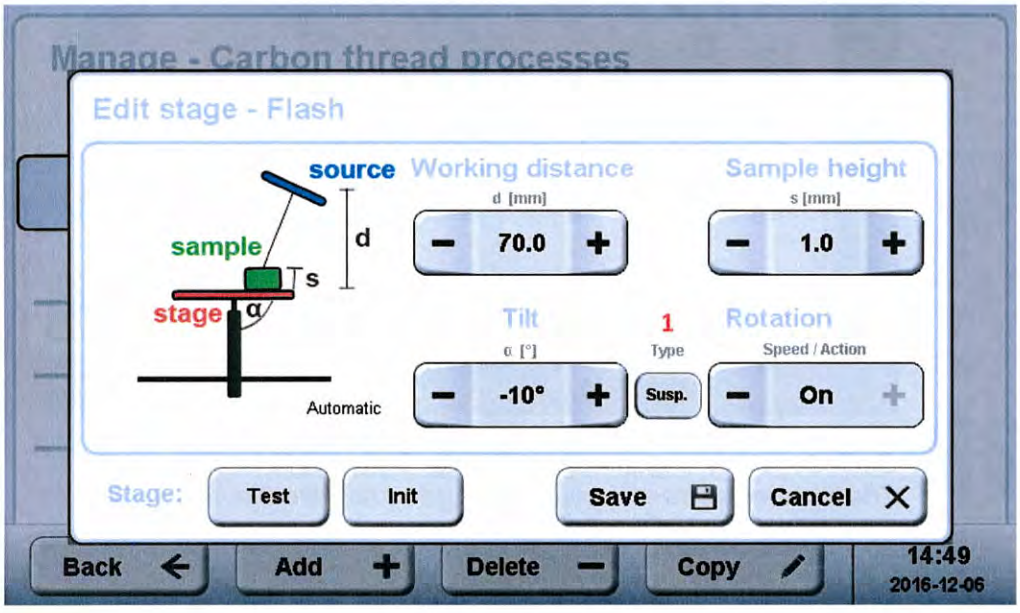


When a sample is especially heat sensitive there is the material "carbon thread low power" available. The evaporation temperature is lower but with increased pulse duration.

The method defines if the thread is pulsed or flashed (1). By ticking or un-ticking the quartz usage box (2), it is defined how many pulses (or flashes) are done (3) or if the process is finished by a thickness threshold (4). In case the thread was mounted doubled to reach higher thickness, the double thread box must be ticked (5).

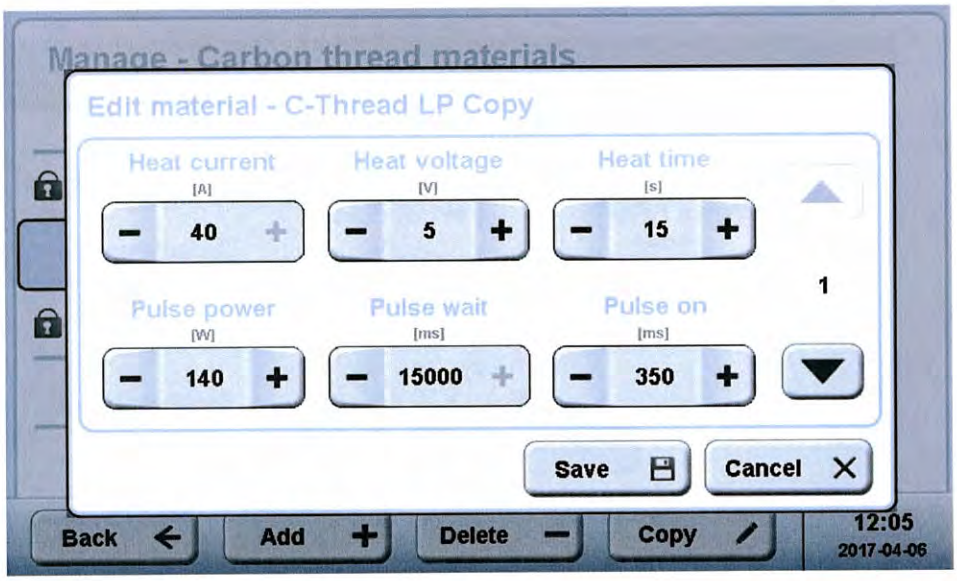


Defining the sample height ensures that the working distance is kept constant. The carbon thread source is angled 25° towards the stage. Tilting the stage influences the coating angle. Rotation can be either set to continuous or a 120° turn after each pulse (1). Settings can be checked by pushing the Test button. Init stops the testing and moves the stage to the init position.

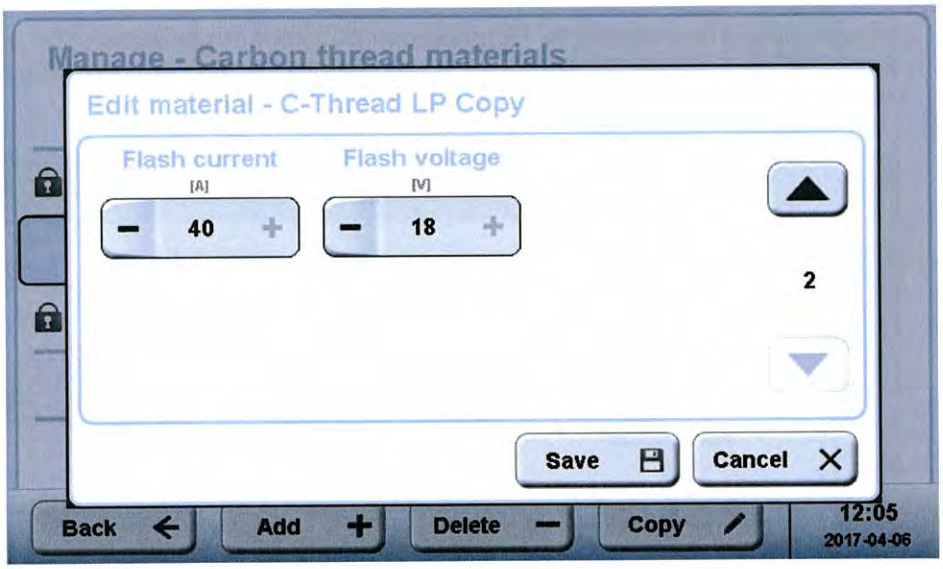


4.6.3 Carbon thread materials

New carbon thread materials can be defined to adjust the pulsing or flashing characteristics. Open Menu, tab file and material management. Select an existing material or add a new one. Set the parameters for the degassing process (heat current, heat voltage and heat time). Pulse power is the value the instrument tries to reach (adjusting current and voltage accordingly). Time between the pulses and duration of a pulse is defined.



Flash current and voltage are a limit. The flash voltage can be adjusted to desired value.



Each thread is degassed separately before it is used.
The system waits after outgassing to stabilize the vacuum.

4.7 Sputter coating

Magnetron sputter coating is performed using ionized argon to create a plasma. The argon-ions are accelerated by high voltage and directed towards the source via a magnet where they collide with the target and displace surface atoms. Due to this collision, the surface atoms are directed towards the area below the target and coat the sample. This coating process can be more directional (sputtering at better vacuum low 10^{-3} mbar) or diffuse (more even coating on a bigger surface and fissured samples, sputtering at low 10^{-2} mbar). This also influences the coating rate (diffuse means slower rate) and the grain size (directional means finer grains). With the quartz thickness measurement (QSG) the layer thickness can be calculated because of the changed quartz crystal resonance frequency (3.8).

Targets

Various targets can be supplied by Leica Microsystems for the EM ACE600 for example:

- Gold
- Gold-Palladium
- Platinum
- Platinum-Palladium
- Silver
- Chromium
- Tungsten
- Iridium
- Copper
- Nickel

Argon gas supply

The working gas (argon) must be supplied under a pressure of ~500 mbar (+/- 100 mbar) maximum. The gas may be supplied via a fixed line or from a gas bottle. The gas should be at least 99.99 % pure.
After choosing and starting a protocol, the system will perform the following steps automatically.

- Pumping until purge vacuum ($1x10^{-4}$ mbar) is reached
- When reaching the purge vacuum the set number of purge cycles is executed
- Pumping until base vacuum is reached
- Turbo pump reduces pumping speed to stand by
- Letting in argon to reach working vacuum
- Stabilizing plasma
- Pre-sputtering, if target requires (to clean the target from oxidation and enable a stable sputter rate)
- Starting the sputtering process by opening the shutter and starting rotation (if set to rotate)

Unclean targets can cause plasma instability and therefore abort the process. Only using Leica targets can insure problem-free sputtering.

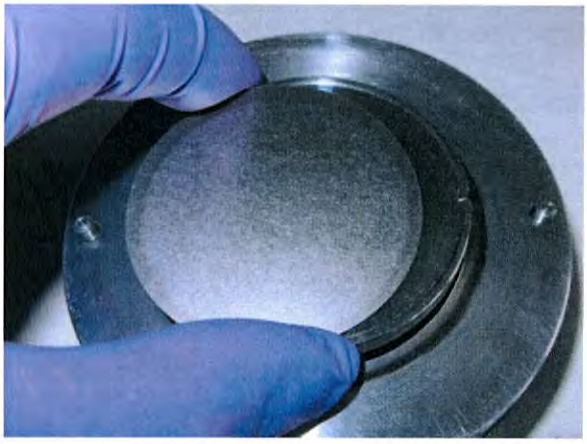
Rotation should be used for the evaporation, only then a homogeneous distribution can be ensured.

- Termination of sputtering by either time or thickness
- Closing the shutter
- Displaying the results of the process (thickness and time)
- Venting or staying in vacuum

4.7.1 Loading the sputter target

Make sure the instrument is vented and open the source cover (1).
Unplug the connector (2).
Unscrew the two sputter head screws to remove the flange (3).

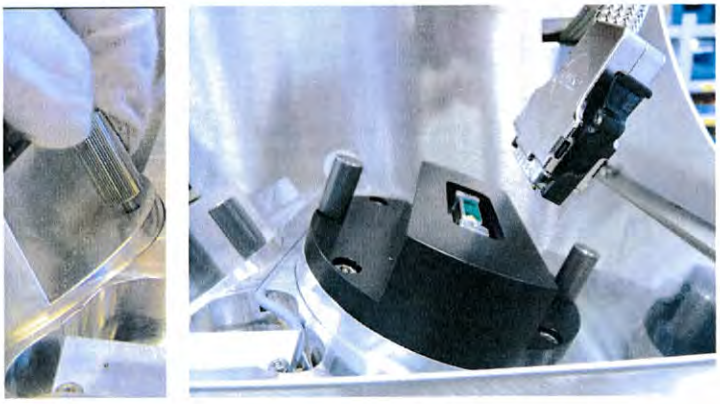
Remove the bayonet ring by turning and insert the sputter target.



Fix target by gently tightening the bayonet ring.

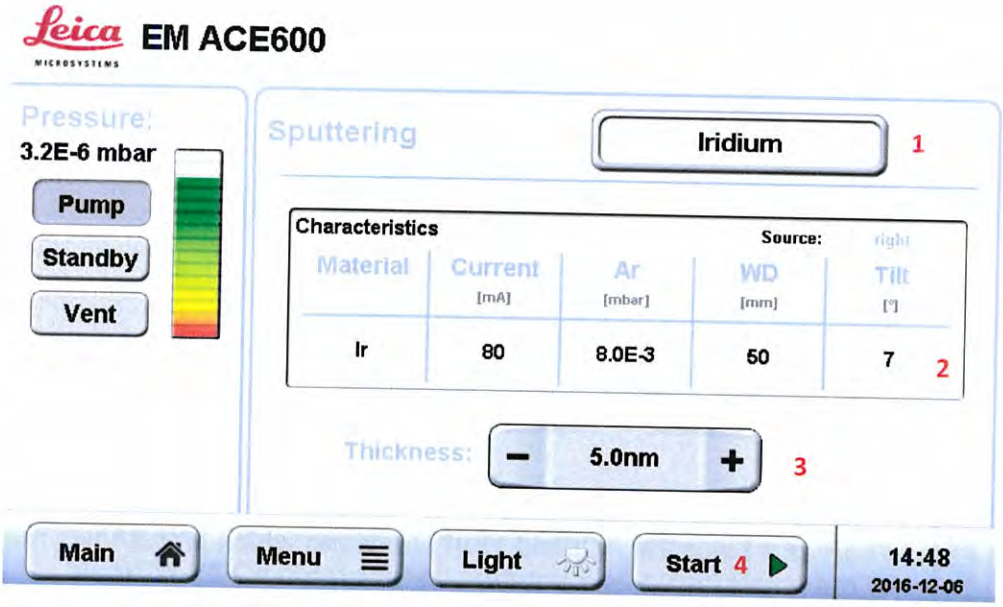
Tighten the ring by hand only.
There is a Leica EM ACE600 YouTube video which also shows the loading of the target http://www.youtube.com/watch?v=Qj3Y-WfNbvM

When the target is secured, replace the sputter head, gently tighten the fastening screws and connect the cable and close the cover.

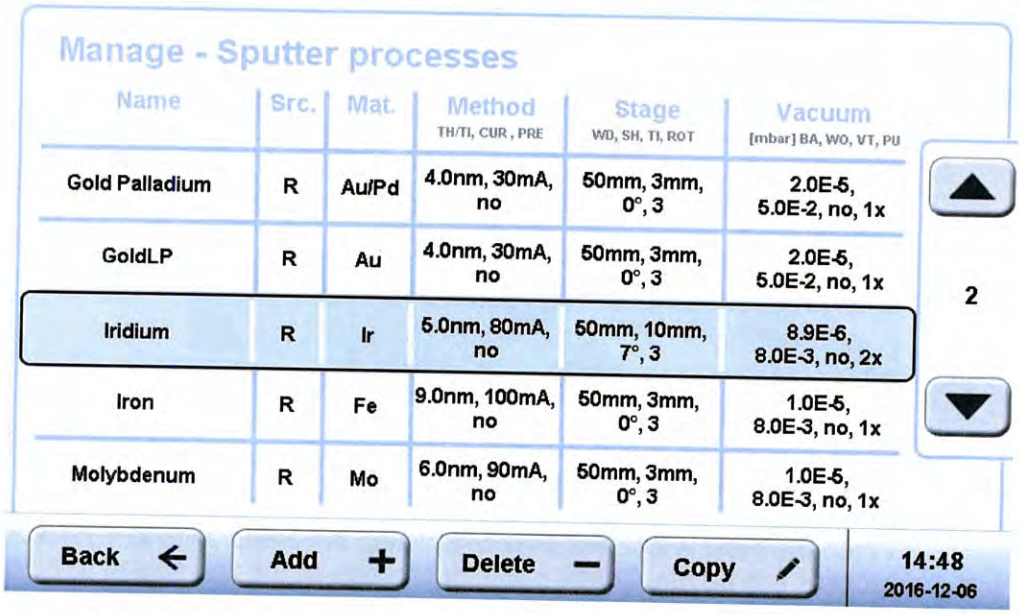


4.7.2 Choosing a sputtering protocol

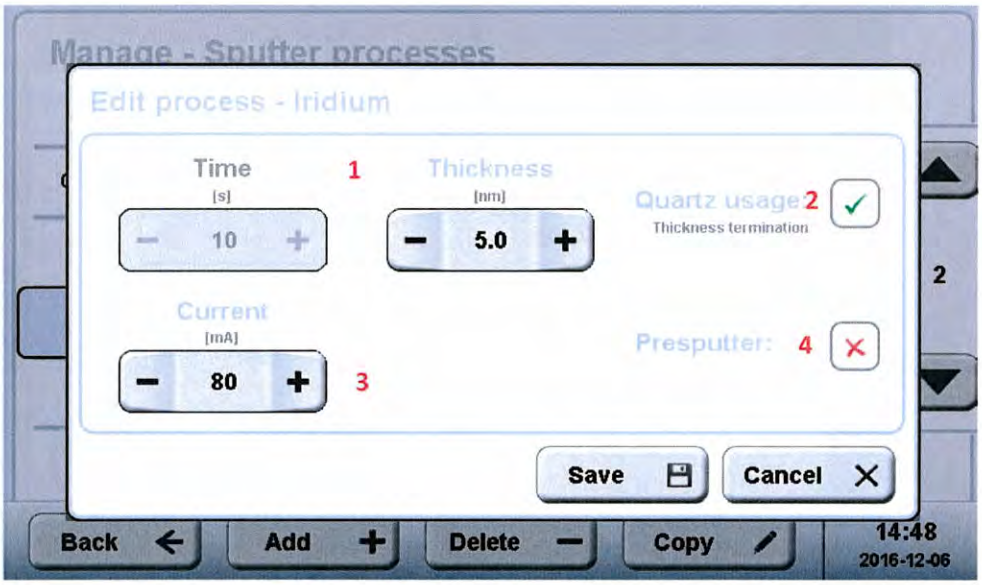
When the head is inserted after completing the preparation in 4.7.1 a sputtering process can be run. Select a sputter process on the first screen to enter the process screen. In the library of recipes (1) all stored protocols are available and can be chosen. Tapping on the characteristics of the protocol (2) opens the list of recipes. There, the parameters for the process can be changed and saved. Only thickness can be adjusted on the process screen (3). Once everything relevant for the coating process is defined, the process can be started (4).



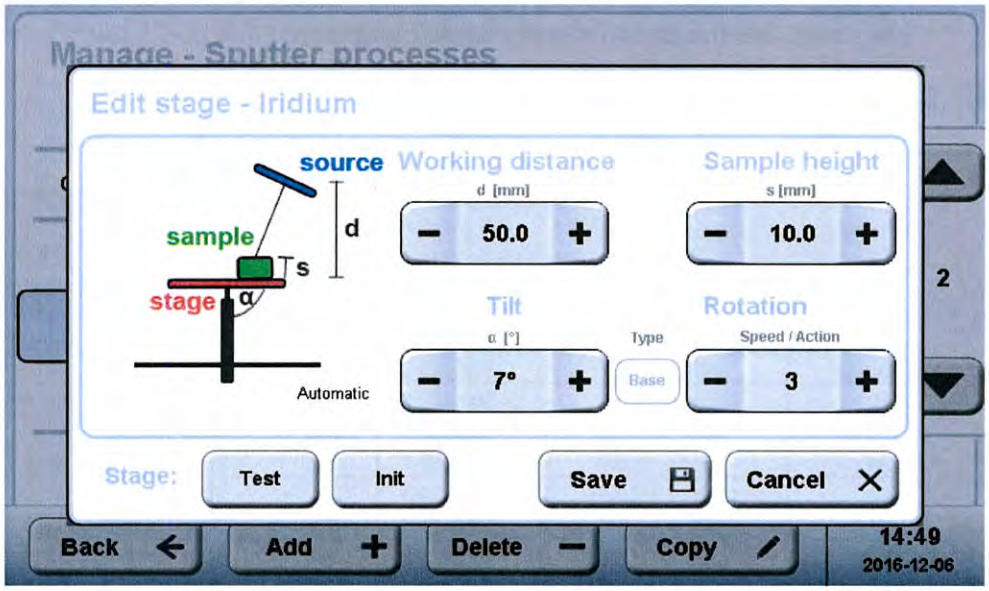
Select a protocol by tapping on it. Once it is marked, by tapping on a specific category, the parameters can be changed. Alternatively, a protocol can be copied and then modified or a new one added.



The method defines if the sputter process is finished by a time or certain thickness (1) by ticking or un-ticking the quartz usage box (2). Also, the sputter current is set (3) and if pre-sputtering is performed (4).

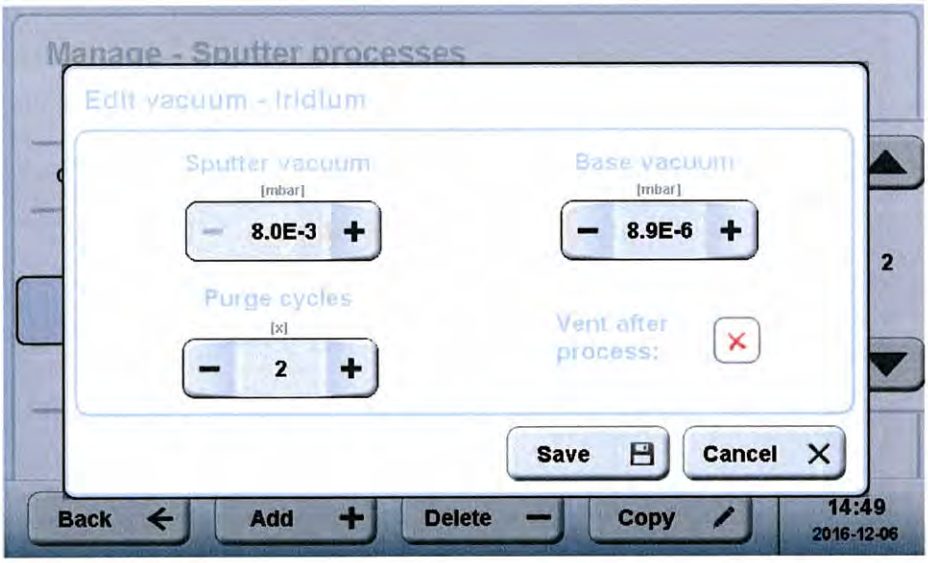


Defining the sample height ensures that the working distance is kept constant. The sputter source is angled 25° towards the stage. Tilting the stage influences the coating angle. Rotation speed can be set from 1 to 5 (equals to 20 rpm) Settings can be checked by pushing the Test button. Init stops the testing and moves the stage to the initial position, such as abandoning the edit stage screen.



Two kinds of vacuum have to be defined. The vacuum which needs to be reached before the sputter process starts (=base vacuum) and the sputter vacuum which will be adjusted by letting argon gas in. Purging flushes argon gas through the tubes into the chamber to clean out other molecules.

If the focus is on fast coating rather than finest layers, a low base vacuum can be set and the turbo pump run in standby. The sputter vacuum will be reached much faster in this way.



Purge cycles: Argon is let in for 10 seconds and then pumped for 30 seconds.

Sputter material:
Density is the specific weight (g/m3) of the material. Set if pre-sputtering is required. Set the pre-sputtering current and time.

4.7.3 Parameters for sputter coating

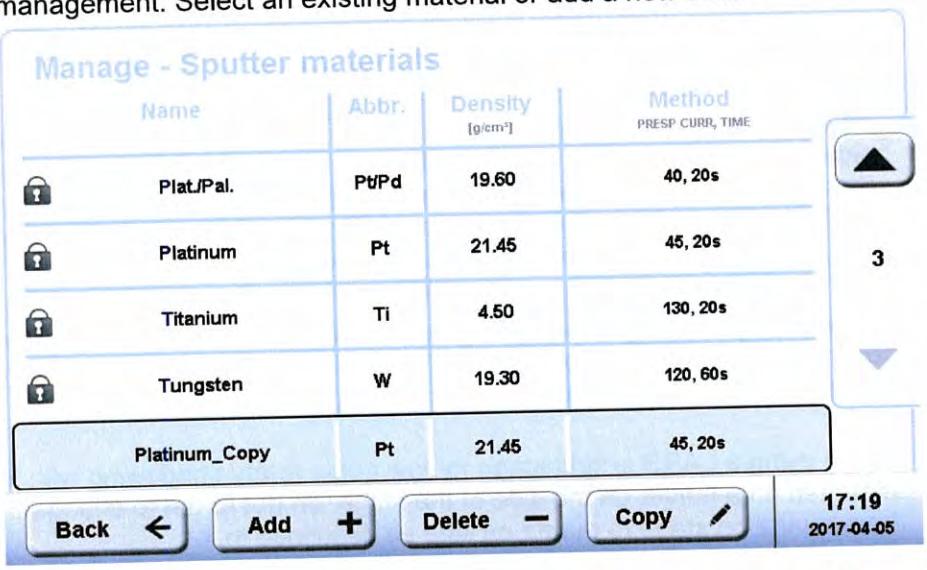
Parameter sugestions for ACE600											
Material	Current in mA	Presputtering in s *	Thicknes s nm	Time	Sputter Vaccum mbar	WD mm	Rotation (1-5)	Tilt	Purge Vacuum	Base Vacuum **	Expected rate app. ***
Au	30	-	4	50	5x10-2	50	3	no	8x10-5	8x10-6	0,1 nm/s
Au/Pd	30	-	4	50	5x10-2	50	3	no	8x10-5	8x10-6	0,07 nm/s
Pt	35	-	4	50	5x10-2	50	3	no	8x10-5	8x10-6	0,07 nm/s
Pt/Pd	35	-	4	50	5x10-2	50	3	no	8x10-5	8x10-6	0,07 nm/s
Ag	35	30	4	50	4x10-2	50	3	no	8x10-5	8x10-6	0,1 nm/s
Cr	110	120	4	10	8x10-3	50	3	no	2x10-5	3x10-6	0,44 nm/s
W	90	60	4	10	8x10-3	50	3	no	2x10-5	3x10-6	0,4 nm/s
Ir	80	-	3	10	8x10-3	50	3	no	2x10-5	3x10-6	0,1 nm/s
Al	100	60	9	60	1x10-2	50	3	no	5x10-5	5x10-6	0,15 nm/s
Ti	100	60	4	50	1x10-3	50	3	no	5x10-5	5x10-6	0,12 nm/s
Md	90	60	6	15	8x10-3	50	3	no	5x10-5	5x10-6	0,4 nm/s
Ni	100	60	10	40	2x10-2	50	3	no	5x10-5	5x10-6	0,25 nm/s
Cu	60	30	10	50	2x10-2	50	3	no	5x10-5	5x10-6	0,2 nm/s
Co	100	60	4	50	2x10-2	50	3	no	5x10-5	5x10-6	0.08 nm/s

* all sputter currents 10% higher than the sputter current (to remove the oxid layer)
** To safe time, the base vacuum can be reduced to the 10-5 range
*** This rate is only a very rough estimation

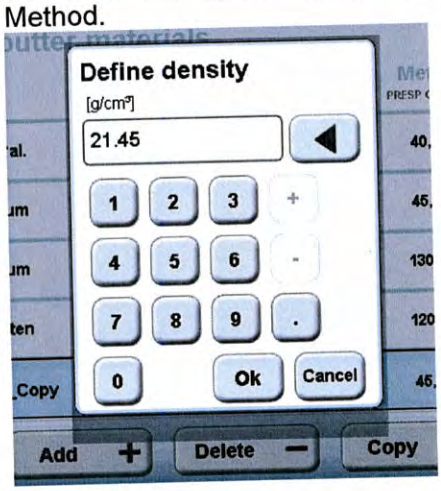
In case the vacuum or plasma cannot be stabilized, check if the argon line is open.

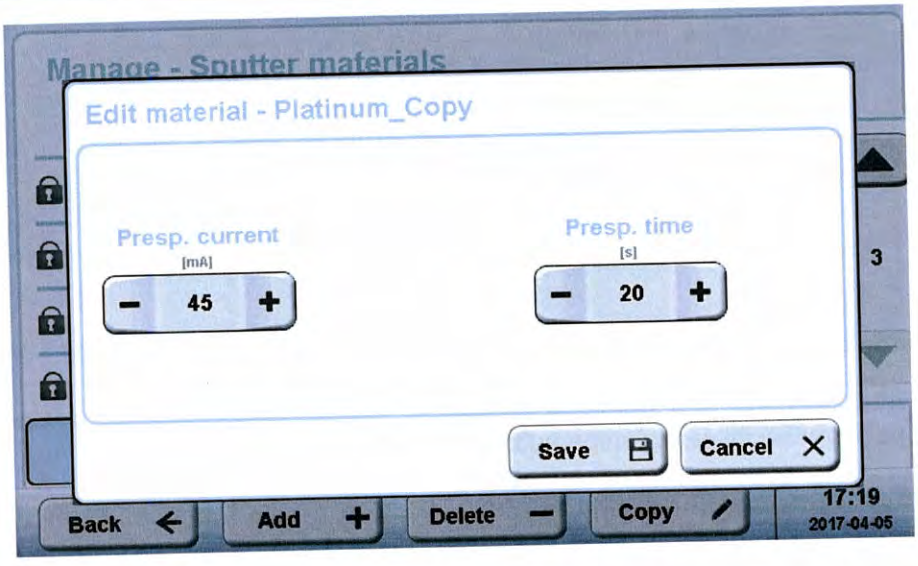
4.7.4 Sputter materials

New sputter materials can be defined. Open Menu, tab file and material management. Select an existing material or add a new one.



Define the density of the new material and the pre-sputter time and current under Method.





6. Troubleshooting

Leica EM ACE600 – Hint/Error/Warning List			
Code	**Title**	**Message (Text)**	**Description**
System (Panel) Specific:			
E0000	Error	System halted due to an unexpected error, Restart system	Software crash (exception handling) > Restart software immediately.
E0001	Error	Controller comm. Error, Restart system	No controller communication established. Check status LED and software version. Try restart or update.
E0002	Error	Pump comm. Error, Restart system	No turbo-pump communication established. Check cable or H485 controller on HiVac PCB.
W0003	Warning	Cannot load configuration file	Configuration (cfg.ini) not loaded correctly. Auto-repair in software when restarting.
W0004	Warning	Specific image is missing	Specific image could not be loaded. Maybe UI update-process went wrong.
W0005	Warning	Cannot load method related file	Unable to load method related file > Processes and sequences not detected.
W0006	Warning	Service interval diaphragm pump exceeded, Service diaphragm pump	Diaphragm pump service interval exceeded. Reset interval in software after service.
W0007	Warning	Service interval turbo pump exceeded, Service turbo pump	Turbo service interval exceeded. Reset interval in software after service.
W0009	Warning	Turbo current consumption too high, Service diaphragm pump	Turbo current too high. Stop pumping and wait.

W0010	Warning	Turbo temperature too high, Service diaphragm pump	Turbo temperature over-heat. Stop pumping and wait.
W0011	Warning	Critical disk space, Back-up files before clean up?	Not enough memory left on device. Clean up device > Delete old logs, screenshots and update folders.
E0012	Error	No pump calibration table found, please calibrate pump to ensure correct behaviour	No pump calibration file found. Calibrate pump in service.
E0013	Error	No available coating method detected, Restart system	No available coating method controller detected. Check communication cables and HiVac controller status.
W0014	Warning	Service interval gauge exceeded, Service gauge	Gauge service interval exceeded. Reset interval in software after service.
W0016	Warning	Gauge pressure out of bounce, Restart system	Invalid gauge pressure value received. Check gauge connection or restart controller.
E0017	Error	Sudden Vacuum Break Down; Check Valves and Device For Leaks	Vent after the Valve, then Open the FSA-Valve, Pressure Drop
E0018	Error	Vacuum Timeout; Check Valves and Device For Leaks	
W0019	Warning	Side Stage, Working Distance Lower than 80 mm	
HiVac Controller Specific:			
W1300	Warning	No quartz detected	Quartz not detected. Warning only active in debug mode.

W1301	Warning	Quartz usage period exceeded, Change quartz to guarantee valid measurement	Quartz usage period exceeded after measured value > 6.1 MHz or < 4 MHz
E1500	Motor error	Lift motor error detected	Initialization of lift motor failed. Try re-initialization and learning.
E1302	Process	Process terminated, Thickness not increasing (timeout), Check quartz and try again	No thickness increase in a specific time -> necessary for all methods to detect if film-thickness can be reached during process -> Check source or quartz and try to run process again
E1303	Process	Process terminated, Quartz unstable, Change quartz to guarantee valid measurement	Quartz unstable -> Measuring of frequency before process has to be stable to guarantee valid measurement -> Change quartz in case and try to run process again
E1600	Motor error	Shutter motor error detected	Initialization of shutter motor failed. Try re-initialization and learning.
E1601	Motor error	Shutter motor not connected, Check cable and restart system	Shutter motor not detected during software init. Restart or check cable connections.
E1700	Motor error	Rotation motor error detected	Initialization of rotation motor failed. Try re-initialization and learning.
E1800	Motor error	Tilt motor error detected	Initialization of tilt motor failed. Try re-initialization and learning.
W1900	Pump fault	Door open, please close the door	Process / Pumping aborted - Check door sensor.
W1901	Pump fault	Cover open please close the cover	Process / Pumping aborted - Check cover sensor.
E1902	Process	head (1) not connected, Connect cable	Process aborted - Specific head not connected!
E1903	Process	head (2) not connected, Connect cable	Process aborted - Specific head not connected!

W1904	Process	Process terminated, head (1) over-temperature	Process aborted - Head-temperature overheated! Temp. > 65°C
W1905	Process	Process terminated, head (2) over-temperature	Process aborted - Head-temperature overheated! Temp. > 65°C
E1100	Error	No gauge detected, Restart system	No gauge detected at start-up of software. Restart device.
Carbon Thread Controller Specific:			
W4001	Warning	No thread available	No threads detected. Abort process only after resistance calculation.
W4002	Warning	All threads exhausted	Process stopped - All threads exhausted in process, but still some pulses to proceed (or thickness not reached) > Abort process
W4003	Warning	# of threads available, # of flashes not possible	Process stopped - Amount of existing threads smaller than desired number of flashes
E4011	Process	Process terminated, no power detected, Check door and cover	Process aborted - Carbon Thread supply not powered. Check door and cover sensors
E4012	Process	Process terminated, Main supply voltage fault, Check door and cover	Process aborted - Carbon Thread mains relay not switched on. Check door and cover sensors
E4013	Process	Thread Measuring Timeout; Restart Process	
E4014	Process	Supply Off Response Timeout	
Sputtering Controller Specific:			
E2001	Process	Process terminated mains supply voltage fault, check door and cover	HV-board not supplied. Check door and cover sensors
E2002	Process	Process terminated, mains supply voltage out of range <85 V	Process - aborted. Mains supply voltage out of range (<85 V)! Check if right voltage is delivered by the network

E2003	Process	Process terminated mains supply voltage out of range 150<>210 V	Process - aborted. Mains supply voltage out of range! (150<>210 V) Check if right voltage is delivered by the network
E2004	Process	Process terminated, Mains supply voltage out of range >250 V	Process stop. Mains supply voltage out of range! (>250 V) Check if right voltage is delivered by the network
E2005	Process	Process terminated, Current not reached, Check target and sputter source	Process aborted - Unable to reach sputter-current. Check if pressure is valid or wrong or no target is used.
E2007	Process	Process terminated, Line voltage fluctuations	Process aborted - Line voltage fluctuations too big!
E2009	Process	Process terminated, Sputter source short circuit! Check target and sputter source.	Process aborted - Short-circuit because of invalid assembly of head, ring or target. Check deposited solid material on shutter
E2010	Process	Process terminated, ignition fault, Check argon flow, Check target and sputter source	Process aborted - Unable to establish plasma ignition.
E2011	Process	Process terminated, Sputter current could not be stabilized	Process aborted - Unstable plasma current. Unclean target could be the reason, clean with isopropanol and try again.
E2012	Process	Process terminated, High voltage board defect, please contact service	Process aborted - High voltage board defect > Change board, since output cannot be controlled anymore
E2018	Process	Operation Response Timeout	The control unit cannot stabilize the voltage in the sputter head.
W2019	Warning	Purge Base-Vacuum (1.0E-4 Mbar) Timeout. Process Anyway?	Begin Sputter using Standby Mode
Glow discharge specific:			
E2109	Process	Process terminated, Short circuit in glow-discharge, Check shutter panels	Process aborted - Short-circuit because of invalid assembly of plates. Check deposited solid material on shutter

E2110	Process	Process terminated, Ignition fault, Check air valve and vacuum	Process aborted - Unable to establish plasma ignition.
E2111	Process	Process terminated, Discharge current could not be stabilized	Process aborted - Unstable plasma current.
Cryo Controller Specific:			
E8002	Process	Process terminated, Unable to reach desired temperature, Check N2 Dewar empty	Process aborted - Reaching reference temperature timeout
E8003	Process	Dewar empty	
E8004	Process	Etching Temperature lower; LN2 empty?	
VCT Specific:			
E1401	Process	VCT Transfer Terminated: Stage Initialization Timeout!	
E1402	Process	VCT Transfer Terminated Stage Position Incorrect!	
E1403	Process	Dock Not Closed	
E1404	Process	Dock Not Open	
E1405	Process	Shuttle Not Closed	

E1406	Process	Shuttle Not Open	
E1407	Process	No Min. Dock Pressure In Interval (>100 mbar)!	
E1408	Process	No Min. Purge Pressure In Interval (> 100 mbar)!	
E1409	Process	Pump Does Not Reach Min. Pressure. Continue?	
E1410	Process	No Dock Connected	
E1411	Process	No Shuttle Connected	
W1412	Process	Shuttle Already Under (Good) Vacuum (P < X mbar)	
E-Beam Controller Specific			
E9001	Warning	E-Beam supply already switched on	Process aborted - Could not switch on power due power is still active
E9002	Warning	Invalid high-voltage value, Set valid parameter and try again	Process aborted - Invalid parameter (voltage) sent
E9003	Warning	Invalid current value, Set valid parameter and try again	Process aborted - Invalid parameter (current) sent

E9004	Process	Process terminated, Chosen e-beam head not supported, Check head connection	Process aborted - Selected head not connected -> Check head configurations in service or cable connection to head
E9005	Process	Process terminated, E-beam board defect, Please contact service	Process aborted - Board defect
E9006	Process	Process terminated, No mains voltage on filament voltage supply	Process aborted - Mains supply not on. Check head supply / door / cover
E9007	Process	Process terminated, No mains voltage on high-voltage supply	Process aborted - Mains supply not on. Check head supply / door / cover
E9008	Process	Process terminated, Filament resistance too high, Check filament	Process aborted - Change filament -> Filament broken or short circuit inside head (clean source)
E9011	Process	Process terminated, E-beam voltage / current not stabilized.	Process aborted - Voltage / current not stabilized -> Restart process or check source
E9012	Process	Process terminated, Operation response timeout	Process aborted - Communication response timeout occurred -> Unable to stabilize or comm. Error -> Restart device
E9013	Process	Filament Stabilization timeout; Restart Process	
Evaporation Controller Specific Process			
E5000	Warning	Evaporation supply already switched on	Process aborted - Could not switch on power due power is still active
E5001	Process	Process terminated, Reference voltage incorrect, Set valid parameter and try again	Process aborted - Invalid parameter (voltage) sent
E5002	Process	Process terminated, Reference current incorrect, Set valid parameter and try again	Process aborted - Invalid parameter (current) sent

E5004	Process	Process terminated, Internal ref. Voltage not ok, Check head connection	Process aborted - Internal head voltage not correct -> Check head connection (service / device tab)
E5005	Process	Process terminated, Output voltage not ok. Restart device.	Process aborted - Output voltage not correct -> Check head connection, head supply or restart device (service / device tab)
E5007	Process	Process terminated, insufficient contact in source. Check source mounting.	Process aborted - Resistance too high -> Contact insufficient -> Check source mounting / rod
E5008	Process	Process terminated, short-circuit in source. Check source mounting.	Process aborted - Resistance too low -> Short circuit or change rod
E5009	Process	Source Exhausted (Contact Loss)	
E5010	Process	Source Exhausted (Short Circuit)	
E5012	Process	Process terminated, operation response timeout	Process aborted - Communication response timeout occurred -> Unable to stabilize or comm. Error -> Restart device