



PL Engineering Ltd.

THERMOELECTRIC MATERIAL INGOTS METER DX8075

User Guide



Moscow, 2018

version 1.00

WARRANTY

PL Engineering LLC warrants that the Ingots Meter DX8075, if properly used and installed, will be free from defects in material and workmanship and will substantially conform to PL Engineering's publicly available specification for a period of one (1) year after date of the Ingots Meter DX8075 was purchased.

PL Engineering LLC also provides a 3-month warranty for the following parts and components included in the standard delivery set of the product: the cables, program slices and documentation

If the Ingots Meter DX8075 fails during the warranty period PL Engineering will repair the Ingots Meter DX8075 or replace it or its parts.

For the warranty support a Consumer can address to the office of the company PL Engineering or its sales representative.

The product repaired or replaced in whole or in part, will have the warranty period counted as one (1) year from initial shipment but not less than 3 months upon shipping of repair or replacement.

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INTRODUCTION

This User Guide is intended for studying the Ingots Meter DX8075 (further the DX8075) for the incoming control of the Seebeck coefficient of ingot and slices, as well as the Seebeck coefficient and electrical conductivity of ingots of thermoelectric (TE) material based on Bi_2Te_3 taking into account the polarity (n/p) and contains all the necessary data and illustrations, sufficient for a correct operation.

The Ingots Meter DX8075 provides measurements of the following parameters of thermoelectric material.

Parameter measured	Units	Designation	Values	Accuracy, %
Seebeck coefficient	mV/K	α	100...300	3
Electrical conductivity	1/(Ohm·cm)	σ	300...2000	5

Samples of the material should meet the following dimensions:

Parameter	Units	Min	Max
<i>Ingot</i>			
Length	mm	40	110
Diameter	mm	20	25*
<i>Slice</i>			
Thickness	mm		30
Diameter	mm	20	25*

Note: * - larger diameter is available on request.

For the measurements, the samples should be prepared in an appropriate way. The order of preparation will be described further.

The facility works under the control of a computer with the software installed. The commands from a computer are processed by the control block.

The device has a degree of automation, allowing to realize measurement of parameters in one cycle for ingots (along one axis) or over the section of a slice according to some law of coordinates changing at a given ambient temperature.

The Ingots Meter DX8075 allows performing research, acceptance, qualification, periodic and other kinds of TE material testing.



1. SPECIFICATIONS

Technical specifications of the machine are given in the table.

Parameter	Units	Values
Step between the measurement Points, d	mm	0.1-100
Accuracy of the Probe Positioning, Δx	mm	0.02
Positioning Repeatability, δx	mm	± 0.04
Total Probe Travel Length, L	mm	0...200
Voltage Range, U	mV	0.01...2
Voltage Accuracy, ΔU	μV	± 3.5
Ambient Temperature Accuracy, ΔT_{amb}	K	0.5
Sample Electric Current, I	A	0.5 – 5.0
Power Supply, AC V	V	220+10/-15
Power Consumption, P	W	<200
Operation Temperature, T_a	$^{\circ}C$	$+25 \pm 4$
Ambient Humidity, RH	%	<80

2. STANDARD KIT

#	Name	Note
1	Main unit	
2	Power supply cable	
3	USB cable	

3. ARRANGEMENT AND OPERATION

Item designations in the figures correspond to item designations given in Section 2. "Standard Kit".

Further in the text of a designation in brackets correspond to the designations in figures.

The measuring part of the facility is a measuring table on which the sample and the probe head are established. Mutual positioning of the probe head of a sample is made by the robot.

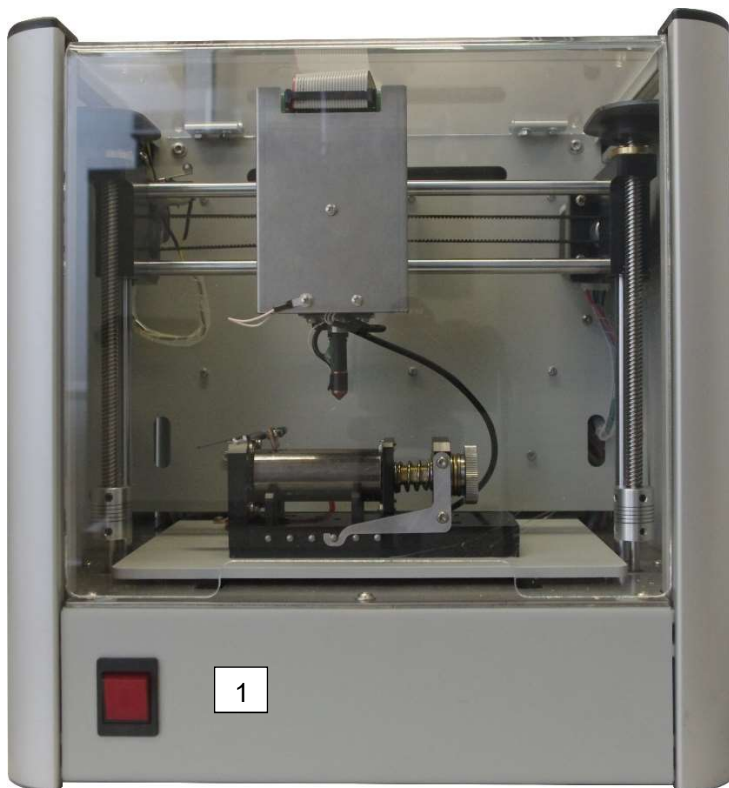
The device control and processing of signals are build in main unit and control by commands from a computer.

3.1. Connection Procedure

Item designations in the figures correspond to item designations given in Section 1 "Standard Kit".

Further in the text of a designation in brackets correspond to the designations in figures.

- Connect the usb cable to the main unit (2) and to the free usb port on PC.
- Plug in the supply cable (3). Be sure the power source is ~220 V (50 Hz)
- Turn on the power switch (1)



DX8075 front view



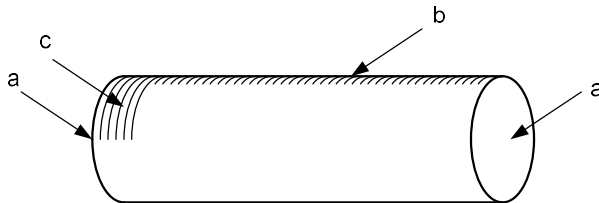
DX8075 back view

3.2. Samples Preparation

3.2.1. Ingots

- Check the face surfaces of an ingot. If they do not satisfy to the conditions of perpendicularity of 1 degree and flatness of 0.1 mm, it is necessary to make a treatment of the face surfaces.
- Sand-paper places of connection of electrodes
 - a. Sample face surfaces

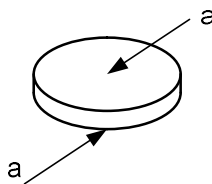
- b. Cylinder general axis along which the measurements will be carried out
- c. Contact area of the top electrode



- Wash the sample with a soap in the water
- Treat the sample by a clean gasoline
- Treat the sample by ethanol
- Wipe copper contacts of the measuring table and those of the probe by ethanol
- Place the sample on a clean surface and keep it 2 hours at room temperature.

3.2.2.Slices

- Check the face surfaces of a slice. If they do not satisfy to the conditions of flatness of 0.1 mm, it is necessary to make a treatment of the face surfaces.
- Sand-paper the face surfaces



- Wash the sample with a soap in the water
- Treat the sample by a clean gasoline
- Treat the sample by ethanol
- Wipe copper contacts of the measuring table and those of the probe by ethanol
- Place the sample on a clean surface and keep it 2 hours at room temperature.

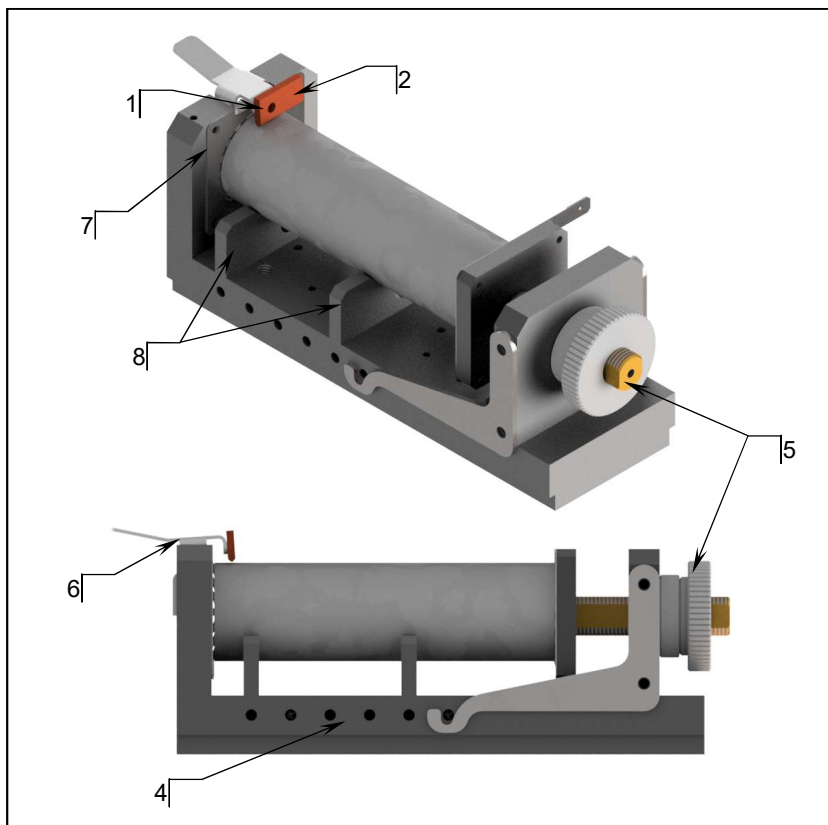
3.3. Sample installations

3.3.1. Ingot

Not to stain the sample, put on the gloves.

Place the sample on a measuring table according to the figure below, having made the following actions.

- Screw the panel of the thermocouple of the "cold end" (1) onto the top measuring electrode (2) of the measuring table
- Using the locking pins (4), move the right stop so that the distance between the left leading electrode (7) and the right stop is slightly larger than the ingot
- Rotating the handle of screw (5), move apart the leading electrodes to the distance slightly less than the ingot length.
- Press the clip arm (6).
- Insert the ingot, leaning it against the supporting slices (8). The orientation of the ingot should be such that the cleaned zones corresponded to the places of connection of the electrodes.
- Press the ingot tightly to the left leading electrode (7).
- Let off the arm of clip (6), fix the ingot and be visually be sure that there is a contact of the top electrode (2) and of the ingot
- Rotating the handle of screw (5), press the right leading electrode to the ingot tightly



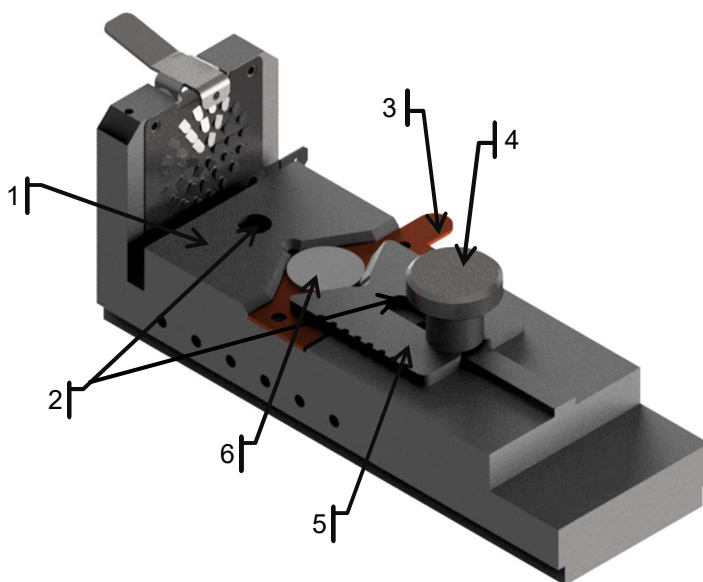
Installation of a sample should provide a good electric contact of the sample all-over the plane of the leading electrodes, as well as both good thermal and electric contact with the top measuring electrode.

3.3.2.Slice

Before starting measuring procedure for slices you need install special bracket for it (1). First of all remove or slide away right leading electrode and remove supporting slices. Than place bracket on top and screwing it with two screws (2).• Screw the panel of the thermocouple of the "cold end" onto the top measuring electrode (3) of the measuring table

Not to stain the sample, put on the gloves.

Place the sample on a measuring table according to the figure below, having made the following actions.



- Weaken the fixing screw (4) and remove holder (5) to the right

- Establish the slice by pressing it tightly to plate (6) and leaning it against two supporting ledges of the plate for slice measurement
- Fix the slice by holder (5) by moving it firmly to the left and turn tightly fixing screw (4).

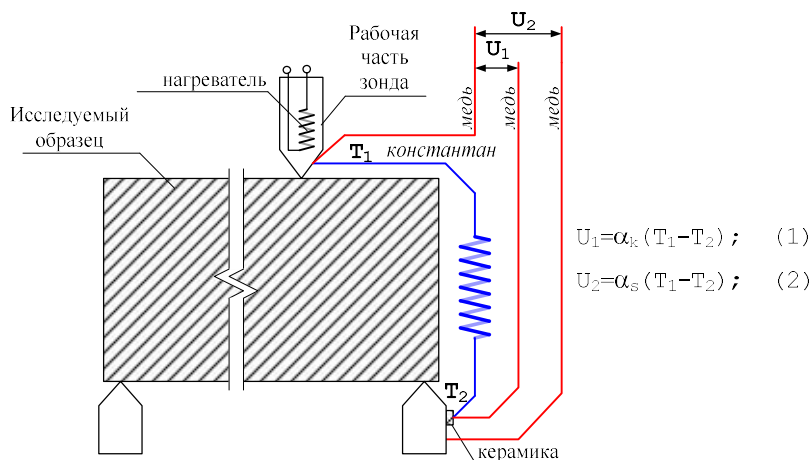
Installation of a sample should provide a good thermal and electric contact with plate (6).

4. MEASURING PROCEDURES

- Prepare the sample and mount it onto the measuring table as shown in Section 3.2. Measure the dimensions of the sample.
- Turn on the control block and perform the measurements – see Section 4.1 and by the software – see Section 5.

4.1. Seebeck Coefficient

The method can be figured out with the help of the following scheme.



There is a heated double probe consisting of a constantan part and a copper part.

The voltage on the constantan probe U_1 is given by:

$$U_1 = \alpha_K(T_1 - T_2) \quad (4.1)$$

where α_K - constantan Seebeck coefficient referred to copper; T_1 - sample temperature close to the probe end; T_2 - base temperature in relation to which the temperature is measured.

The voltage on a sample is voltage on the copper probe U_2 :

$$U_2 = \alpha_s(T_1 - T_2) \quad (4.2)$$

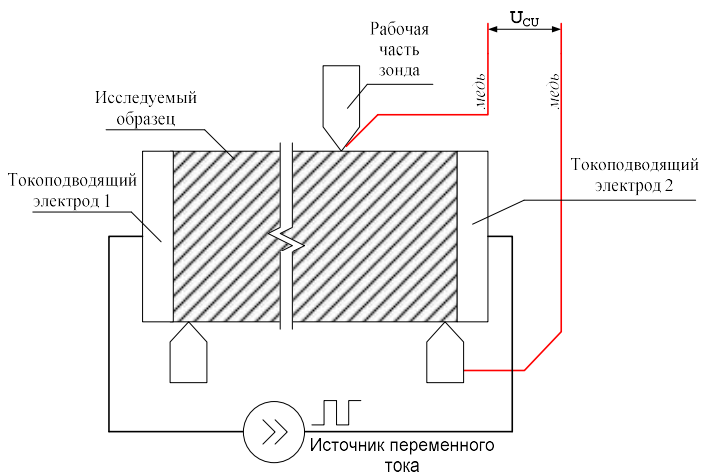
where α_s - sample Seebeck coefficient referred to copper,

From Eqs. (4.1) and (4.2) the sample Seebeck coefficient referred to copper is equal to:

$$\alpha_s = \frac{U_2 \times \alpha_K}{U_1} \quad (4.3)$$

4.2. Electrical Conductivity

Electrical conductivity is measured by the voltage $U(x)$ at AC electric current I as illustrated below.



The value is calculated as:

$$\sigma(x) = \frac{I \times \Delta x}{s[U(x) - U(x - \Delta x)]} \quad (4.4)$$

where Δx - distance between two nearest points; I - sample current, s - sample cross-section, $U(x)$ - potential difference between points x and 0.

5. SOFTWARE

5.1. System Requirements

For a successful installation of the software, the computer should meet the following requirements:

- 512 Mb RAM
- Operating system Windows
- 50 Mb of free space

If you install the software from the CD (it is supposed that the option of automatic loading is on) "Autorun", press the button "DX8075 Application Setup".

If you downloaded the software from the site (<http://www.tec-microsystems.com>), run the file "<PATH>\Dx8075Setup.exe" and follow the instructions, where <PATH> is the path to the file-setup.

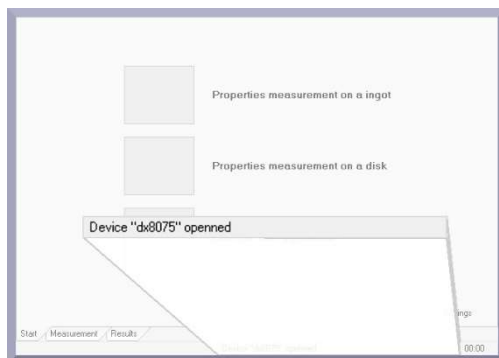


Important! *It is necessary to install the software "DX8075 Application" before the connection of the device to a computer.*

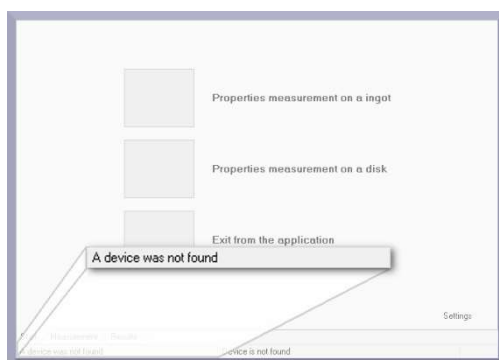


5.2. How to Get Started

1. Turn on the device by the switch "ON-OFF".
2. Switch on the computer and start the program of controlling the device "DX8075". The software is started in a usual way, by a double-click of the mouse on the appropriate tag. After it, the software will try to define (determine) necessary devices for work. In case of a successful detection, the text with devices found will appear on the status bar.

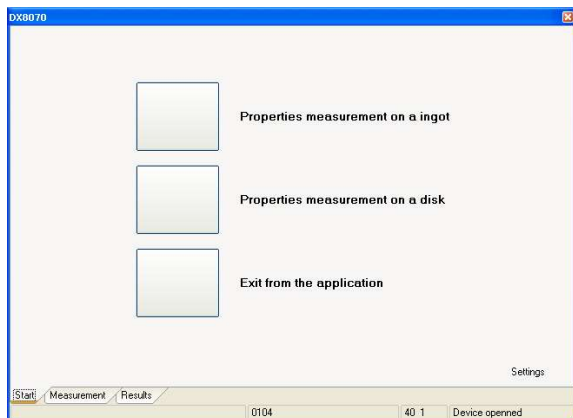


In case of an unsuccessful connection, the message will appear:



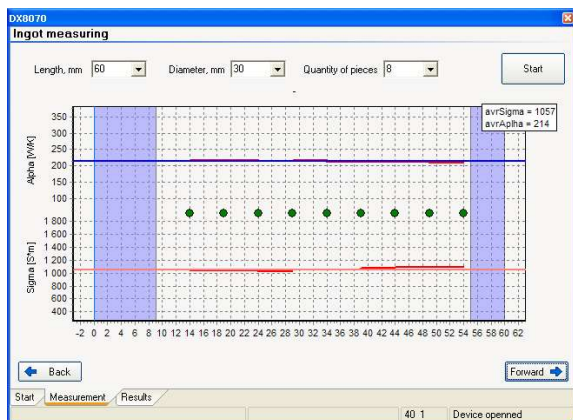
5.3. Main Window

After the device detection, the software main window is loaded:



The main window has a simple interface and allows proceeding quickly to necessary measurements on an ingot or on a slice. For this purpose, it is enough to press a mouse on the appropriate button.

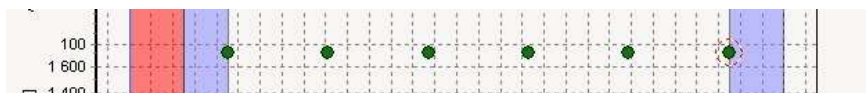
5.3.1. Measurement of Ingots



Fill the ingot parameters in the fields "Diameter", "Length" and "Step".

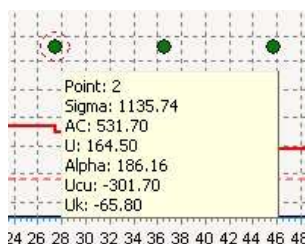
Length, mm	<input type="text" value="60"/>	Diameter, mm	<input type="text" value="30"/>	Quantity of pieces	<input type="text" value="8"/>
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A number of points to measure is set by a number of elements. The more the number of elements, the smaller the step between points. It is not recommended to set the number of elements more than 8. An approximate arrangement of points is given on the plot below.



For beginning to measure, we press button "Start". Measurement on an ingot includes two independent processes: the measurement of electrical conductivity (σ) and that of the Seebeck coefficient (α). After the measurements are over, the dependences of Alpha and Sigma versus the coordinate will be plotted, and the average values will be shown.

For the detailed information on properties of the material in a measured point, it is necessary to put the mouse cursor on a point needed. Within a small time the information will be shown in a separate window.

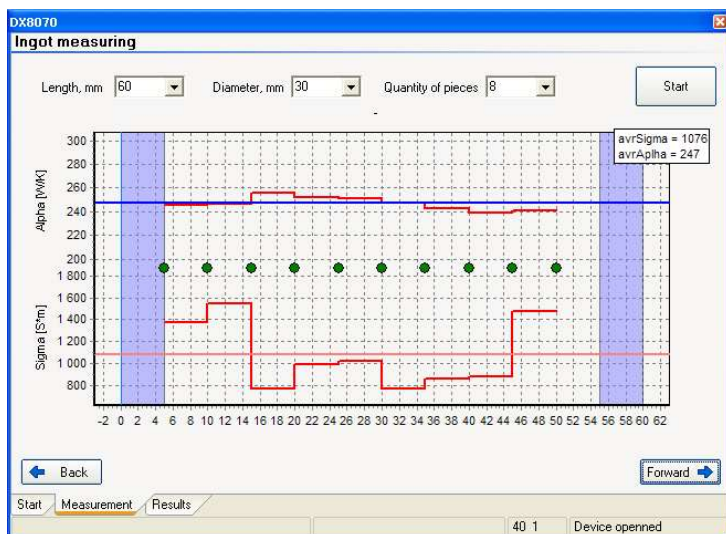


The following parameters are given in this window:

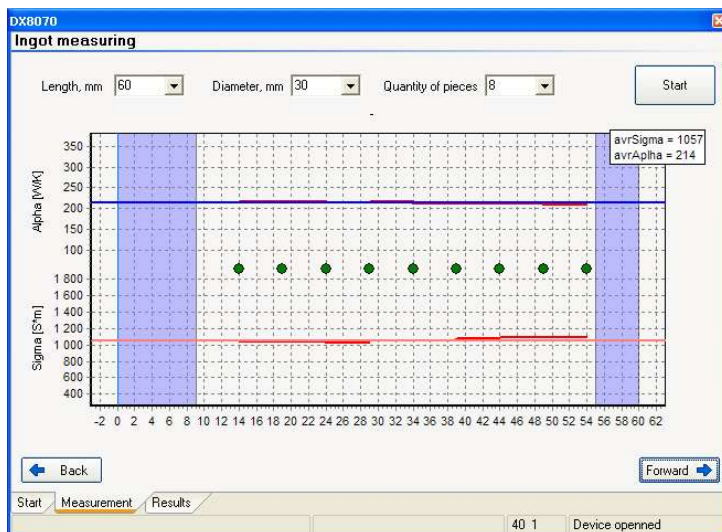
- Point number
- Sigma value (σ)
- AC current
- Copper wire voltage (for σ)
- Alpha value (α)
- Constantan wire voltage (for α)
- Copper wire voltage (for α)

In case of a bad contact between the sample and electrodes, the results can be incorrect. Such a situation is displayed on the diagram by strong fluctuations from the average value. If so, it is recommended to correct the contact and to repeat measurements.

The examples of results of measurements with bad and good contact are given in the following figures.



Bad contact measurements



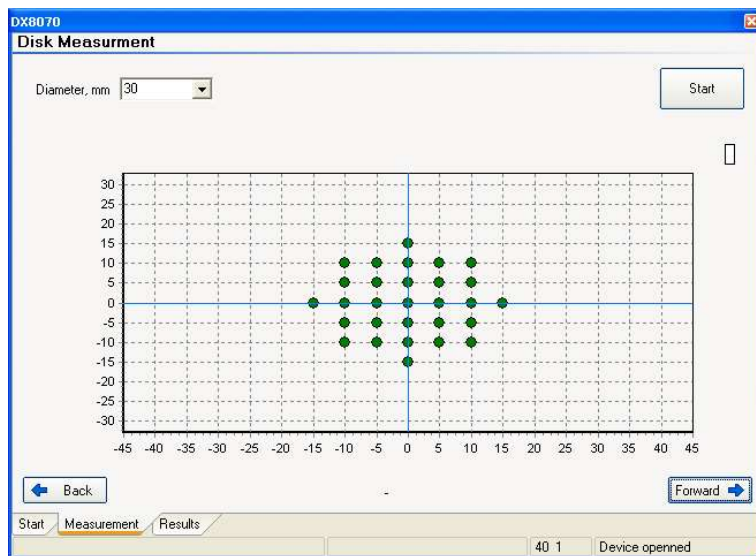
Good contact measurements

5.3.2.Measurement of Slices

Fix the slice (disk) on the measuring table, as recommended.

Measure the slice diameter and write into the corresponding field of the software.

It is only the Seebeck coefficient that can be measured in this mode. To start the measuring procedure, press the button "Start".



5.3.3. Results Window

In this window the summary information on measurements is given. To open the log of the test results, it is necessary to press button "further" after the end of measurements.

The test log offers the following services:

- Results storage
- Earlier results loading
- Results printing

All the actions are done by an appropriate button choice.

DX8070

Sample measurement result

Print Open Save

Passport of the ingot

Supplier name	Date of delivery	Diameter, mm	Length, mm	Weight, g	Material type

Type	Tm(Tr), C	Sigma, $\Omega\text{m}^{-1}\text{cm}^{-1}$	Alpha, $\mu\text{V/K}$	A2S	Date	Operator

Parameters list

Step from begin	Type of conduction	Sigma, $\Omega\text{m}^{-1}\text{cm}^{-1}$	Alpha, $\mu\text{V/K}$	A2S

Start Measurement **Results**

0104 40 1 Device opened

6. PRECAUTIONS

- At operation, maintenance service and checking it is necessary to observe requirements of the Russian Standard "GOST 12.3.019-80", "Service regulations of consumers' electronic devices" and "Rules of a labor safety at operation of consumers' electronic devices", or to apply similar documents of your country.
- The voltage on the contacts of the device at operation is up to 250 V, which is dangerous to human life. Any connections to the device and its maintenance service are only to be done at power switched off.
- Moisture on contacts and internal elements of the device are not allowed. The usage of the device in aggressive environments in the atmosphere of acids, alkalis, oils, etc. is forbidden.
- The connection, adjustment and servicing of the device should only be performed by the qualified experts who have studied this document.

7. MAINTENANCE

Service of the operational device consists of the technical inspection.

At the maintenance service of the device observe the security measures - see Section 6 "Precautions".

Technical inspection of the device should be carried out not rarer than once in three months and includes the following operations:

- Cleaning of the device housing of dust, dirt and extraneous subjects;
- Cables checking;
- Checking of reliability of inter-block connections.

The malfunctions found at the technical inspection should be removed immediately.

Checking of metrological characteristics of the device should be done not rarer than once in 3 years.

If necessary, make the adjustment of the device. It means the operations providing restoration of its metrological characteristics in case of their change during a long operation.



Important! *Necessity of the adjustment is determined by results of the device checking only by the qualified experts of the metrological services carrying out this checking.*

8. MALFUNCTIONS

Possible malfunctions and ways of their elimination are given in the table below.

Appearance	Possible reason	Way of elimination
The program could not contact the control block	Faulty USB cable Necessary drivers are not installed	Malfunction reason elimination
Temperature value is not true	Breakage of a circuit of one of thermal resistances	Malfunction reason elimination



Note. *If a malfunction or a reason is not specified in the table, it is necessary to deliver the device for repair.*



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