

## SPECIFICATION RTM-30-PN-6-S EXTRUDED THERMOELECTRIC MATERIAL

- 1.0. Scope
  - 1.1. This document covers requirements for P- and N-type extruded thermoelectric material in form of round-shape ingots.
  - 1.2. Specification "Spec RTM-30-PN-6-S" is related to fabrication of extruded materials mainly for applications in temperature range  $-40^{\circ}\text{C}$   $+100^{\circ}\text{C}$  (room temperature material).
- 2.0. Applicable documents
  - 2.1. Material Safety Data Sheets are provided on Customer Request.
  - 2.2. Test Data are provided for each ingot lot.
    - 2.2.1. Average ingot resistivity ( $\rho$ ) in units of milliohm\*cm at test temperature of  $25^{\circ}\text{C}$ .
    - 2.2.2. Power factor ( $\text{PF}=\alpha^2(1/\rho)$ ) which is calculated from measured resistivity and Seebeck coefficient ( $\alpha$ ) at  $25^{\circ}\text{C}$ .
  - 2.3. Individual ingot identification is traceable to raw material supply, extrusion run, test data and manufacturing process conditions. This ID number for each ingot with length 120mm includes information about: type of conductivity (P or N), extrusion run number (four digits), ingot number (last digit) in run starting from extrusion beginning.
  - 2.4. An extrusion lot is defined as ingots received within one extrusion run/process made from the same alloyed material batch and the same extrusion conditions.
- 3.0. Requirements
  - 3.1.1. Length
    - 3.1.1.1. 239-248 mm.
  - 3.1.2. Diameter
    - 3.1.2.1. P-type 30.0 mm - 0.8 mm.  
N-type 30.0 mm - 0.8 mm.
  - 3.1.3. Straightness
    - 3.1.3.1. 9 mm maximum deflection over entire length.
    - 3.1.3.2. The cut planes of two ingot ends can be deviated from perpendicular to ingot center line less than 7 degrees.
  - 3.1.4. External appearance
    - 3.1.4.1. Smooth silver gray surface finish.
    - 3.1.4.2. On the cylindrical surface of ingots there are no pits or grooves larger or deeper than 0.2 mm.
    - 3.1.4.3. No ridges greater than 0,2 mm.
    - 3.1.4.4. No chips or cracks besides chips at ingot end arisen during cutting. These chips must be not deeper than 1,0 mm and not longer than 12 mm.
    - 3.1.4.5. No scratches deeper than 0,2 mm.
    - 3.1.4.6. Protrusions on the ends of ingots up to 1 mm high, up to 12 mm long, up to 1.5 mm thick.
    - 3.1.4.7. In addition to the marking applied by the laser engraver, technological inscriptions on the ends of ingots are allowed.
  - 3.1.5. Internal appearance
    - 3.1.5.1. No chips, pits or voids greater than 0,2 mm within ingot.
    - 3.1.5.2. No fractures parallel to extrusion direction.
    - 3.1.5.3. No fractures perpendicular to extrusion direction.
  - 3.2. Electrical performance at  $25^{\circ}\text{C}$ 
    - 3.2.1. Resistivity (milliohm\*cm)
      - 3.2.1.1. Nominal 1.000
      - 3.2.1.2. Minimum 0.850
      - 3.2.1.3. Maximum 1.150
        - 3.2.1.3.1. Resistivity interval is to be binned into 6 groups with resistivity increments of 0,050 milliohm\*cm.
        - 3.2.1.3.2. Ingot ends will be marked by attached marking sticky paper dot to indicate resistivity binning as follows in units of milliohms-cm
          - 3.2.1.3.2.1. 0.850-0.900 Black dot
          - 0.900-0.950 Blue dot

## **SPECIFICATION RTM-30-PN-6-S EXTRUDED THERMOELECTRIC MATERIAL**

- 0.950-1.000 Green dot
- 1.000-1.050 Yellow dot
- 1.050-1.100 Red dot
- 1.100-1.150 White dot
- 3.2.1.3.2.2. In the case when ingot resistivity corresponds to number between two bins, higher resisting bin color coding will be used.
- 3.2.1.3.2.3. Average resistivity of every 119,5-124 mm part of ingot is recorded on each ingot using a laser graver.
- 3.2.1.3.2.4. The deflection of resistivity along 239-248 mm part of ingot must be not more than 40 milliohm-cm.
- 3.3. Formula and Process changes
  - 3.3.1. Formula changes must be agreed with Customer before product change. Sample products are provided on Customer request for requalification and approval.
  - 3.3.2. Process parameters must be agreed with Customer before process change. Sample products are provided on Customer request for testing and approval.
- 3.4. Product marking (see Appendix 1)
  - 3.4.1. Every ingot is labeled directly with number of extrusion process and number of ingot position (from head to tail). These IDs are unique and preferably sequential numbers for the material type that allowing traceability to raw materials and extrusion conditions in case of troubleshooting. Ingots are directly labeled by laser graver on cylindrical surface of ingot. So, Customer can see there the number of run, number of ingot in run, average resistivity and power factor (PF).
  - 3.4.2. The data on average electrical resistivity and power factor are indicated (by graver) for first 119,5-124 mm of ingot and for second 119,5-124 mm part of ingot.
  - 3.4.3. Paper color dot is attached on each ingot end and color of dot corresponds to average resistivity of 119,5-124 mm part close to this end.
- 3.5. Traceability
  - 3.5.1. Traceability to the raw materials used in each ingot and process condition is provided via records in "Traveler" (see Appendix 2). Time for maintaining these records must be agreed with a Customer.
- 4.0. Packaging (see Appendix 3)
  - 4.1. Individual ingots are packaged inside plastic sealed (by zip) bags.
  - 4.2. Plastic sealed ingots are tightly packaged in matrix made from foamed polyethylene to avoid movement or contact between ingots during handling and transportation. Ingots with protective polyethylene bags and support matrix are placed inside a plywood box for transportation purpose. Certificates for all packed ingots are placed in shipping box (see Appendix 4 and 5).
  - 4.3. Package (box plus matrix) weight is not more 3,7 kg.
  - 4.4. Shipping box has the following information:
    - 4.4.1. - Name of a Sender
    - Name and address of a Consignee
    - 4.4.2. Description of a Material (P-ingots or N-ingots)

*RusTec*

*RusTec LLC*

office 207, 3 Peschany carier, Moscow 109383 Russia  
Phone +7 (499) 356-61-86, e-mail: [info@rustec-msk.com](mailto:info@rustec-msk.com)  
[www.rustec-msk.com](http://www.rustec-msk.com)

---

**SPECIFICATION RTM-30-PN-6-S**  
**EXTRUDED THERMOELECTRIC MATERIAL**

---

- 4.4.3. Purchase Order Number (if need)
- 4.4.4. - Net Weight
  - Gross Weight

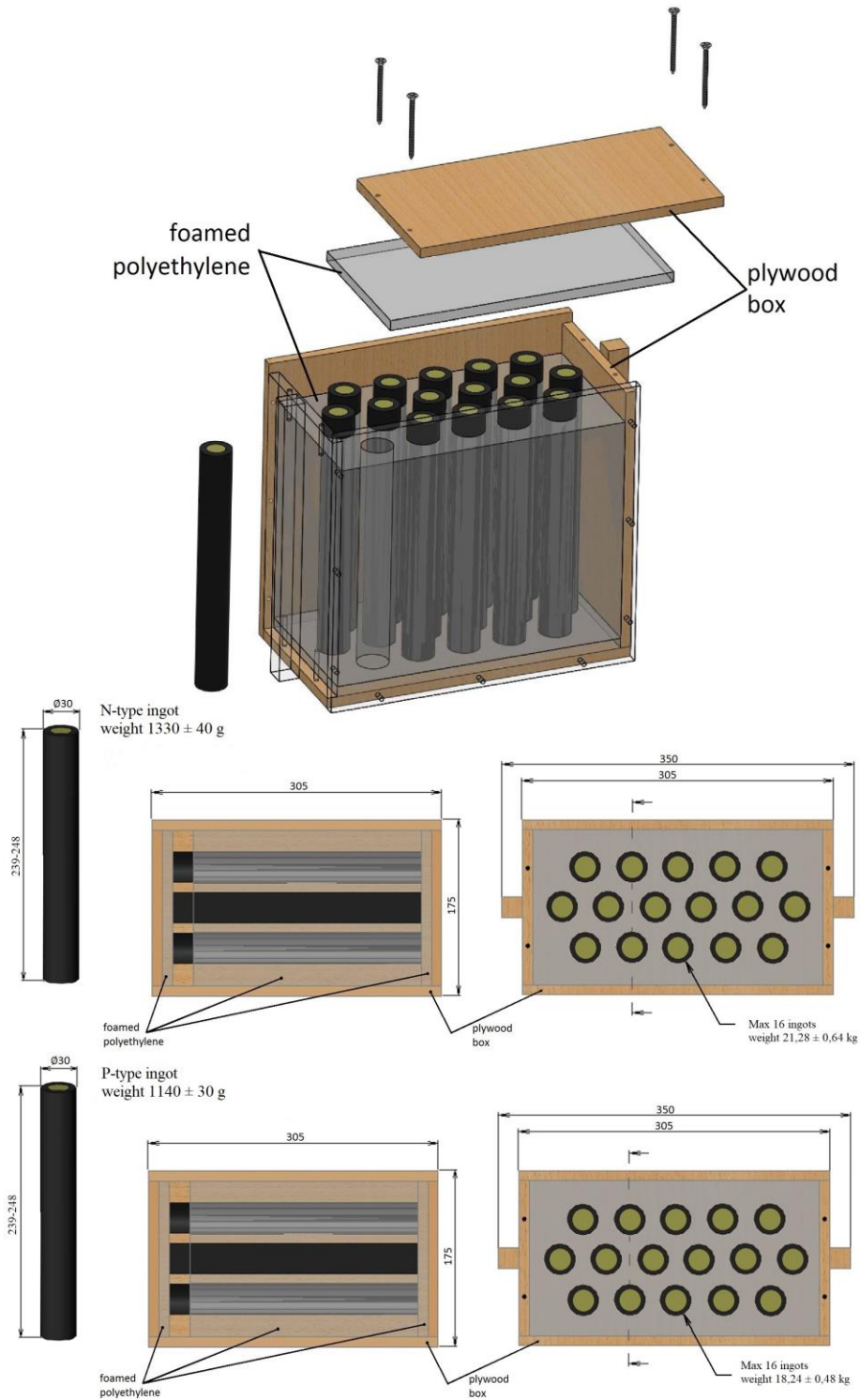
## Product marking



## Карта сопровождения (Traveler)\* (экструдированные слитки/extruded ingots)

Процесс/Process											
Сырье/Raw materials	Te	Bi	Sb	Se							
Поставщик/Vendor											
Партия № / Lot №											
Чистота/Purity «9»											
Очистка/Purification											
Лигатура/Dopant											
Синтез/Synthesis											
Дробление/Crushing											
Брикетирование/Briquetting											
Отжиг/Annealing											
Зеебек/Seebeck [ $\mu\text{v}/\text{K}$ ]											
Экструзия/Extrusion											
Отжиг/Annealing											
Резка/Cutting											
Осмотр/Visual inspection											
Электросопротивление Resistivity [millionhm*cm]	1	2	3	4	5	6	7	8	9	10	11
Замечания/Notes					Resistivity № Процесс Process						

## PACKAGE



## CERTIFICATE P-06

Spec RTM-30-P/N-6-S  
for ingots of  $\text{Bi}_2\text{Te}_3\text{-Sb}_2\text{Te}_3$

1. Type of conductivity - P-type
2. Method of fabrication - extrusion
3. Ingots diameter -  $\text{Ø}30\text{-}0.8$  mm
4. Length - 239-248 mm
5. Resistivity at 25<sup>0</sup>C, total range - 0.850-1.150, (milliohm\*cm)
6. Marking of ingot ends by color paper dot:

black	-	0.850-0.900 milliohm*cm
blue	-	0.900-0.950 milliohm*cm,
green	-	0.950-1.000 milliohm*cm,
yellow	-	1.000-1.050 milliohm*cm,
red	-	1.050-1.100 milliohm*cm,
white	-	1.100-1.150 milliohm*cm.

Exact value of average resistivity and number of fabrication process is indicated onto ingot cylindrical surface by laser graver.

7. Each ingot is placed in individual zip sealed polyethylene bag.

RoHS compliant product.

Quantity, kg (pcs) \_\_\_\_\_

Box№ \_\_\_\_\_

Date \_\_\_\_\_

QC manager \_\_\_\_\_

## CERTIFICATE N-06

Spec RTM-30-P/N-6-S  
for ingots of  $\text{Bi}_2\text{Te}_3\text{-Bi}_2\text{Se}_3$

1. Type of conductivity - N-type
2. Method of fabrication - extrusion
3. Ingots diameter -  $\text{Ø}30\text{-}0.8$  mm
4. Length - 239-248 mm
5. Resistivity at 25°C, total range - 0.850-1.150, (milliohm\*cm)
6. Marking of ingot ends by color paper dot:
  - black - 0.850-0.900 milliohm\*cm
  - blue - 0.900-0.950 milliohm\*cm,
  - green - 0.950-1.000 milliohm\*cm,
  - yellow - 1.000-1.050 milliohm\*cm,
  - red - 1.050-1.100 milliohm\*cm,
  - white - 1.100-1.150 milliohm\*cm.
7. Exact value of average resistivity and number of fabrication process is indicated onto ingot cylindrical surface by laser graver.
8. Each ingot is placed in individual zip sealed polyethylene bag.

RoHS compliant product.

Quantity, kg (pcs) \_\_\_\_\_

Box№ \_\_\_\_\_

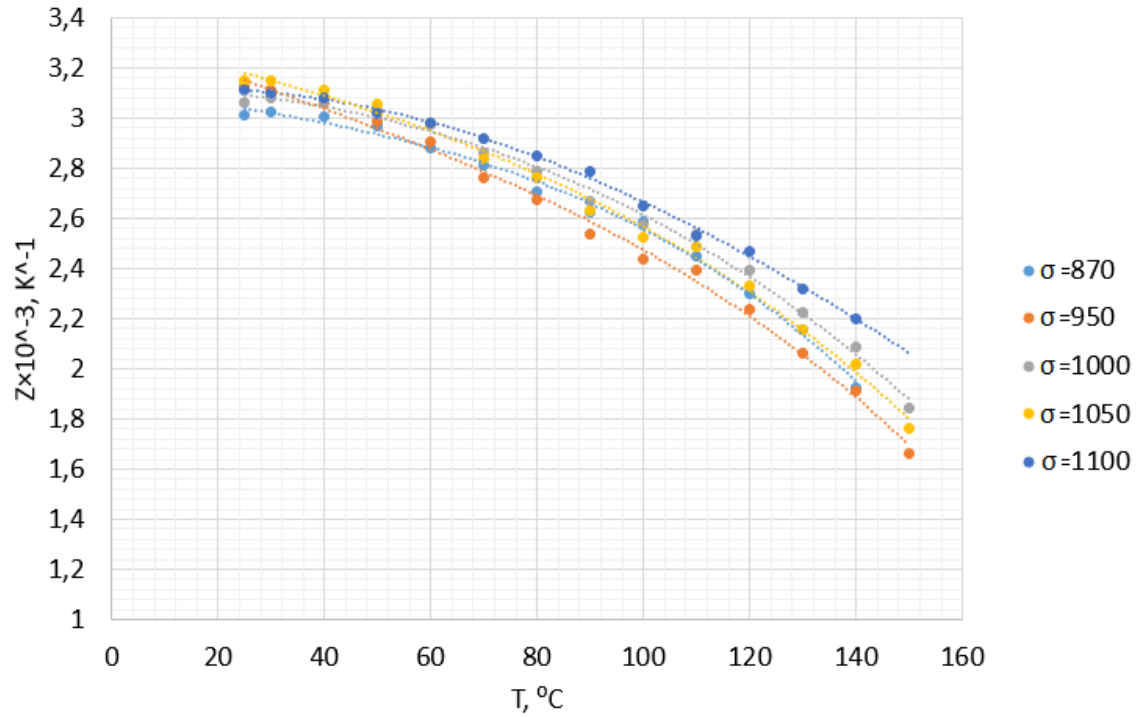
Date \_\_\_\_\_

QC manager \_\_\_\_\_

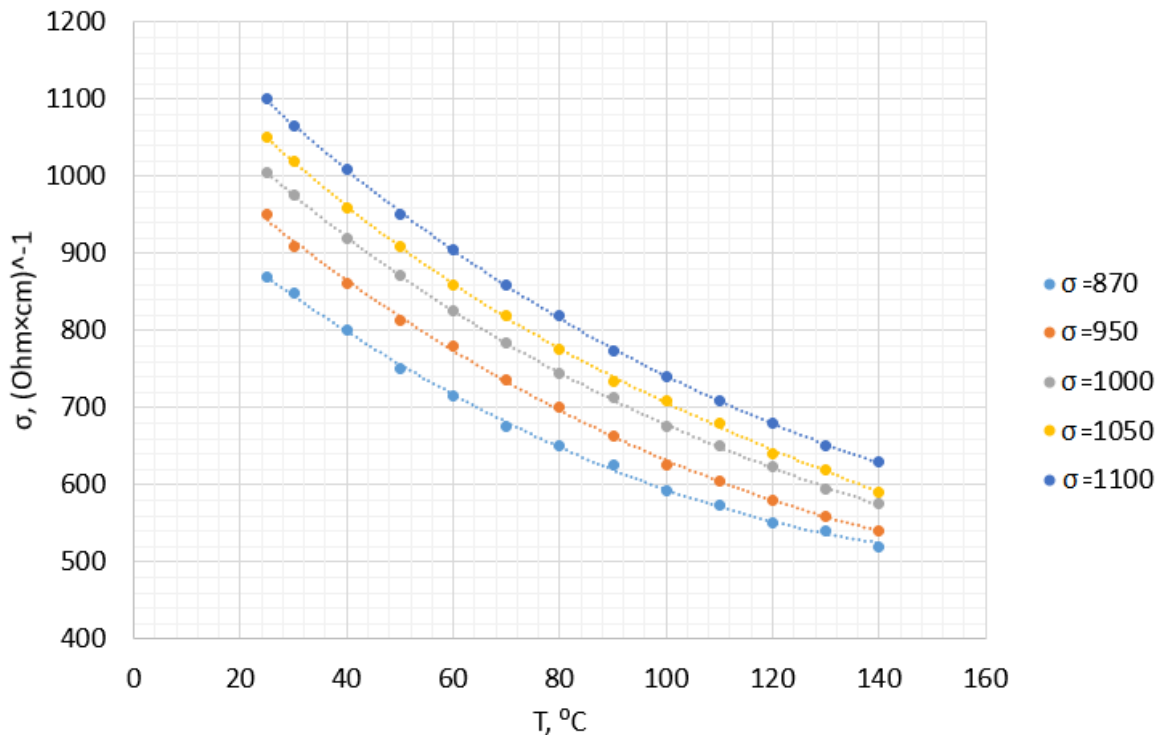


**P-type.**

**Thermoelectric efficiency**

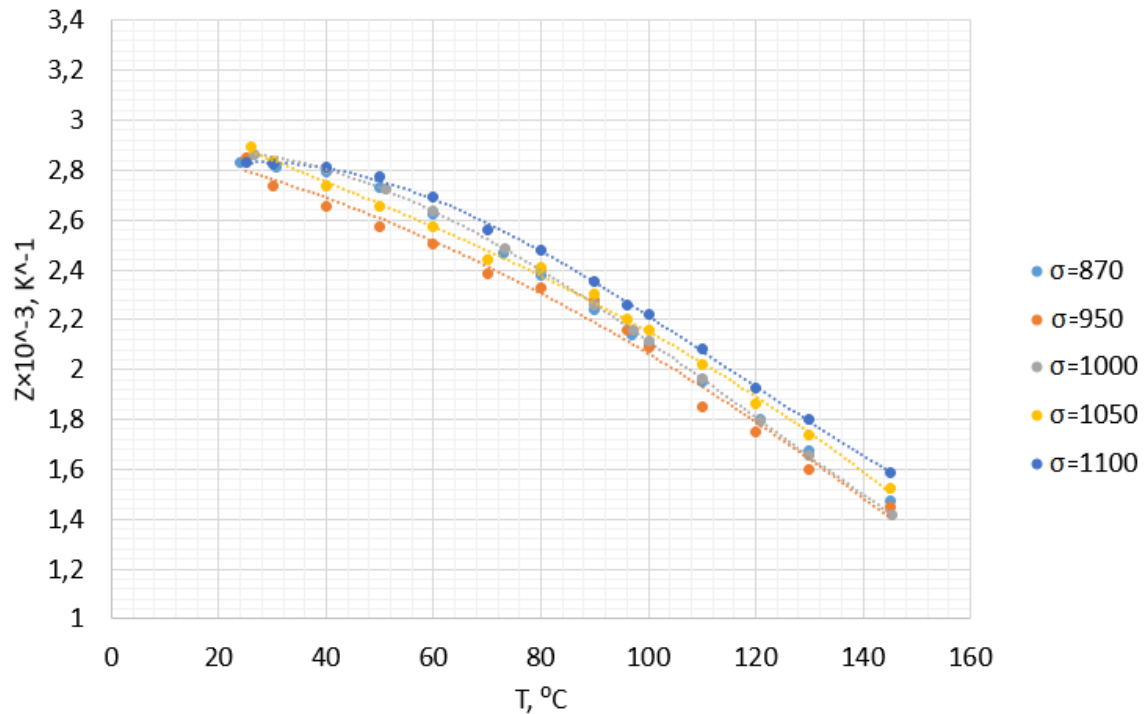


**Conductivity**

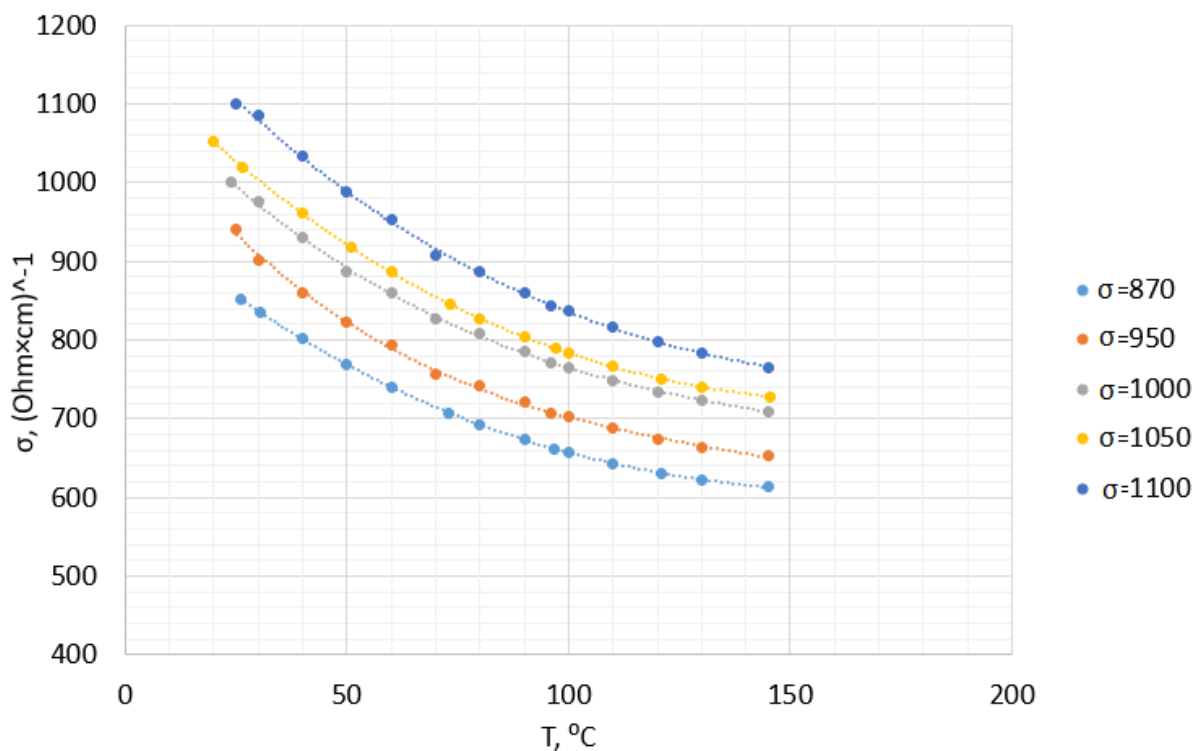


N-type.

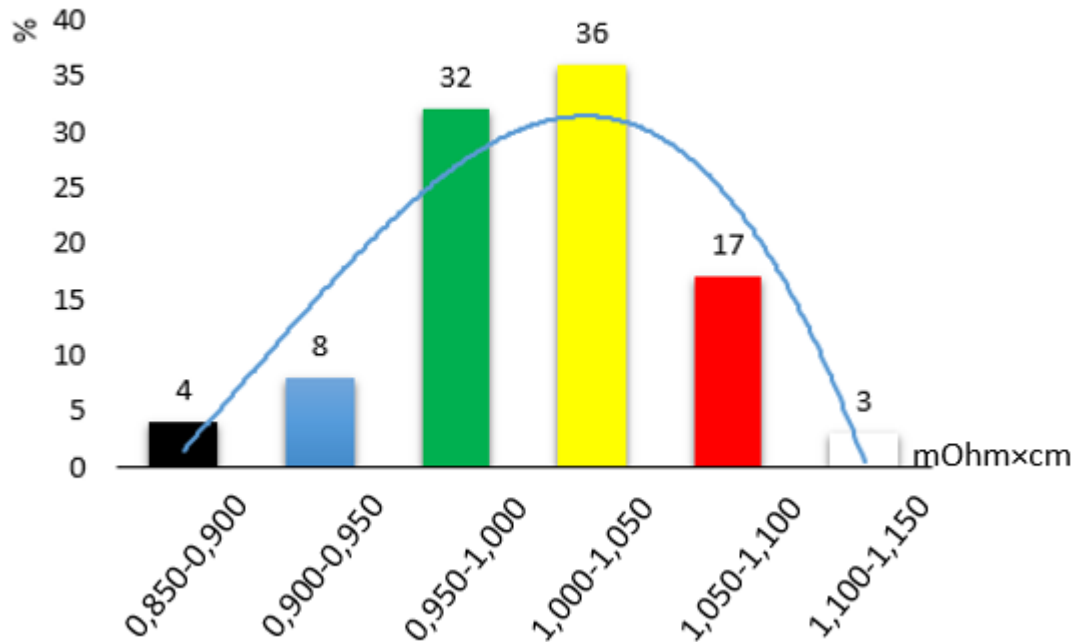
Thermoelectric efficiency



Conductivity



### Distribution Resistivity for P-type



### Distribution Resistivity for N-type

