

# MATERIALS

# REFRACTORY

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# Refractory Metals

**The advantages of refractory metals, Molybdenum, Niobium, Tantalum, Tungsten, at a glance:**

- High melting point
- Low vapour pressure
- Low thermal expansion
- Extremely good corrosion resistance against molten metals and glass

## CHEMICAL & PHYSICAL PROPERTIES

### Mo 42 MOLYBDENUM

Melting point	2610°C
Boiling point	4825°C
Density	10.28 g.cm <sup>-3</sup> (20°C)
Thermal conductivity	138 W.m <sup>-1</sup> .K <sup>-1</sup>
Molar heat capacity	24.06 J.mol <sup>-1</sup> .K <sup>-1</sup>
1 <sup>st</sup> ionization energy	684.3 kJ.mol <sup>-1</sup>
Electrical resistivity	53.4 nΩ.m (at 20°C)
Thermal expansion	4.8 μm.m <sup>-1</sup> .K <sup>-1</sup> (at 25°C)
Vickers hardness	1530 MPa
Mohs hardness	5.5
Young's modulus	329 GPa
Tensile strength	560 - 1150 MPa
Elongation	< 20%

### Nb 41 NIOBIUM

Melting point	2468°C
Boiling point	4927°C
Density	8.57 g.cm <sup>-3</sup> (20°C)
Thermal conductivity	53.7 W.m <sup>-1</sup> .K <sup>-1</sup>
Molar heat capacity	24.60 J.mol <sup>-1</sup> .K <sup>-1</sup>
1 <sup>st</sup> ionization energy	652.1 kJ.mol <sup>-1</sup>
Electrical resistivity	152 nΩ.m (at 0°C)
Thermal expansion	7.3 μm.m <sup>-1</sup> .K <sup>-1</sup> (at 25°C)
Vickers hardness	1320 MPa
Mohs hardness	6
Young's modulus	105 GPa
Tensile strength	125-195 MPa
Elongation	50%

**Ta**  
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**TANTALUM**

Melting point	2996°C
Boiling point	5458°C
Density	16.6 g.cm <sup>-3</sup> (20°C)
Thermal conductivity	57.5 W.m <sup>-1</sup> .K <sup>-1</sup>
Molar heat capacity	25.36 J.mol <sup>-1</sup> .K <sup>-1</sup>
1 <sup>st</sup> ionization energy	761 kJ.mol <sup>-1</sup>
Electrical resistivity	131 nΩ.m (at 20°C)
Thermal expansion	6.3 μm.m <sup>-1</sup> .K <sup>-1</sup> (at 25°C)
Vickers hardness	873 MPa
Mohs hardness	6.5
Young's modulus	186 GPa
Tensile strength	285 MPa
Elongation	> 30%

**W**  
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**TUNGSTEN**

Melting point	3410°C
Boiling point	5555°C
Density	19.35 g.cm <sup>-3</sup> (20°C)
Thermal conductivity	173 W.m <sup>-1</sup> .K <sup>-1</sup>
Molar heat capacity	24.27 J.mol <sup>-1</sup> .K <sup>-1</sup>
1 <sup>st</sup> ionization energy	777 kJ.mol <sup>-1</sup>
Electrical resistivity	52.8 nΩ.m (at 20 °C)
Thermal expansion	4.5 μm.m <sup>-1</sup> .K <sup>-1</sup> (at 25°C)
Vickers hardness	3430 MPa
Mohs hardness	7.5
Young's modulus	411 GPa
Tensile strength	1510 MPa
Elongation	< 2%

F

**MATERIALS**

Neyco provides Molybdenum, Niobium, Tantalum and Tungsten, in wires, rods, plates and foils.

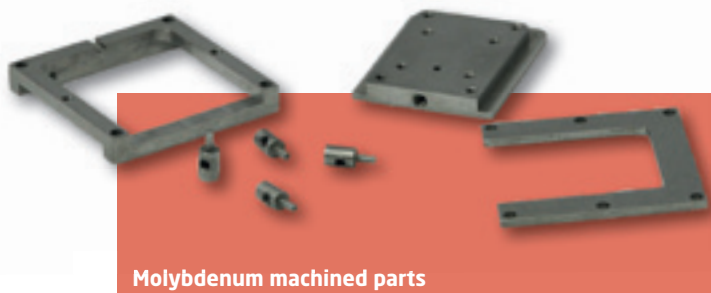
Dimensions: according to request.

**MANUFACTURING ON REQUEST**

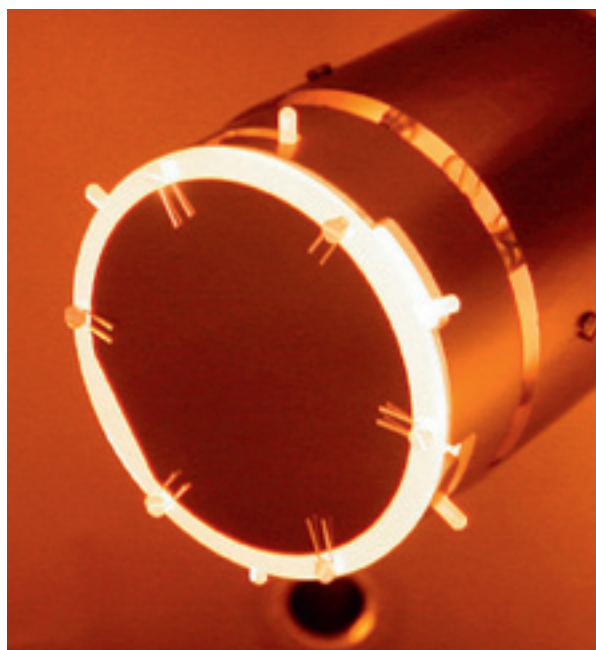
Neyco manufactures according to your drawings or specifications all parts you need in refractory metals:

- Standard or special 1.5", 2" and 3" Molybdenum molyblocks
- Sample holders
- Multi-wafer platens with Molybdenum washers
- Various Molybdenum, Niobium or Tantalum parts
- Mo, Ta, W crucible liners

➔ See Section H in this catalogue about **Crucible Liners**



Molybdenum machined parts



Heated molyblock with Silicon wafer

## SCREWS

Molybdenum and Tantalum screws are produced for high temperature vacuum environments.

We provide in the same materials threaded rods, nuts and washers.



SIZE	LENGTH	TYPE	
M2 to M20	On request	Slotted heads	
		Hexagon heads	
		Hexagon socket heads (Allen)	
		Set screws	
		Nuts	
		Washers	

# Heating Elements

## TUNGSTEN FILAMENTS

Neyco provides single wire and multi-strand filaments for thermal applications, such as:

- Vacuum metallization
- Vacuum lamps
- Electron emission (e-beam)
- Ion neutralization (ion-beam)
- Black Tungsten used as heating resistance (atmospheric pressure)

### EXAMPLES

- Tungsten filaments with 9 strands: 0.76x3x3x1650 mm, purity = 99.95%
- Tungsten filaments with 2 or 3 strands
- Tungsten wires  $\varnothing$  15 to 100  $\mu$ m



## PBN/PG HEATING ELEMENTS

PBN/PG resistance heating elements combine the unique electrical, chemical, and thermal properties of PBN, a dielectric material, and Pyrolytic Graphite (PG), an electrical conductor, to produce a truly advanced heating system.

These non-brittle refractory materials owe their exceptional purity to the high temperature, chemical vapor deposition (CVD) production method. The high thermal conductivity and anisotropy of both materials result in excellent thermal uniformity.

## PERFORMANCE ADVANTAGES

PBN/PG “printed circuit” heaters utilize PBN as an insulating substrate and Pyrolytic Graphite as the resistive element. In non-oxidizing environments, this combination of unique materials delivers performance advantages not available in conventional thermal systems.

- Operating temperatures: 1500°C and higher
- Superior performance in ultra-high vacuum
- Chemically inert to most corrosive gases, liquids
- Unaffected by most molten metals
- Long life, dimensionally and electrically stable
- High resistance for low cost power supplies
- Mechanically durable, thermally shock resistant
- Unaffected by vibration
- Tailored thermal gradients for specific requirements
- Ultra-fast response, low thermal mass
- Power densities: 35 W/cm<sup>2</sup> and higher
- Dielectric, fully dense, ceramic surface
- Often suitable for slightly oxidizing atmospheres

## APPLICATIONS

- PVD
- Ion-implant
- MOCVD
- CVD
- PLD
- PE-CVD

## DESIGN VERSATILITY

We manufacture heaters as flat plates, with surface electrical connections inside the heated area or located outside the heated area on tabs. Heaters can also be made as 3-D elements on chemical vapor deposited (CVD) PBN crucibles and tubes.

PBN/PG Heaters have been made as small as 5 mm diameter, and as large as 300 mm.

Location of the contact tabs provides design flexibility for enhanced thermal uniformity. Resistance patterns can be circular or diagonal, and can have varying web width to tailor local flux. Multiple, independent zones can be incorporated for flexible thermal management.

## PRE-ENGINEERED HEATER SOLUTIONS

Neyco’s Pre-engineered Ceramic Heaters are demonstrated solutions with field-tested designs that offer outstanding thermal stability and performance in applications like epi wafer processing and high temperature process development. They offer the electrical, chemical and thermal properties of combining Pyrolytic Boron Nitride (PBN) and Pyrolytic Graphite (PG) in custom engineered solutions without the time and expense involved in refining and testing a new design.

These pre-engineered designs were once custom solutions. They have since been routinely manufactured to solve common challenges in demanding heating applications, allowing us to pass along a discounted price compared to custom-made heaters. We can also customize these ceramic heaters for your unique application or equipment.



Disc Heater



Disc Heater With Tabs



Rectangular Heater

## ORDERING INFORMATION

- Disc Heaters:

P/N	HEATED DIAMETER inch (mm)	CONTACT SPACING inch (mm)	RESISTANCE AT ROOM T° (Ω)
HTR0041	1.00 (25.4)	0.75 (19.0)	10-16
HTR0042	1.50 (38.1)	1.20 (30.5)	10-16
HTR0043	2.00 (50.8)	1.60 (40.6)	15-25
HTR0044	2.50 (63.5)	2.07 (52.6)	22-35
HTR0045	3.00 (76.2)	2.42 (61.5)	22-35
HTR0062	2.00 (50.8)	1.71 (43.4)	15-25
HTR0063	3.00 (76.2)	2.71 (68.8)	15-25
HTR0064	4.00 (101.6)	3.54 (89.9)	15-25

- Disc Heaters With Tabs:

P/N	HEATED DIAMETER inch (mm)	CONTACT SPACING inch (mm)	RESISTANCE AT ROOM T° (Ω)
HTR0001	0.50 (12.7)	0.70 (17.8)	5-7
HTR0002	0.75 (19.0)	1.35 (34.2)	9-15
HTR0003	1.00 (25.4)	1.50 (38.1)	9-15
HTR0004	1.75 (44.5)	2.50 (63.5)	17-30
HTR0005	2.00 (50.8)	2.50 (63.5)	15-25
HTR0021	1.00 (25.4)	1.73 (43.9)	15-25

- Rectangular Heaters:

P/N	HEATED DIAMETER inch (mm)	CONTACT SPACING inch (mm)	RESISTANCE AT ROOM T° (Ω)
HTR1001	0.98 (25.0)	1.11 (28.2)	7-10
HTR1002	1.97 (50.0)	1.92 (48.8)	11-15
HTR1003	2.95 (75.0)	2.97 (75.4)	16-22