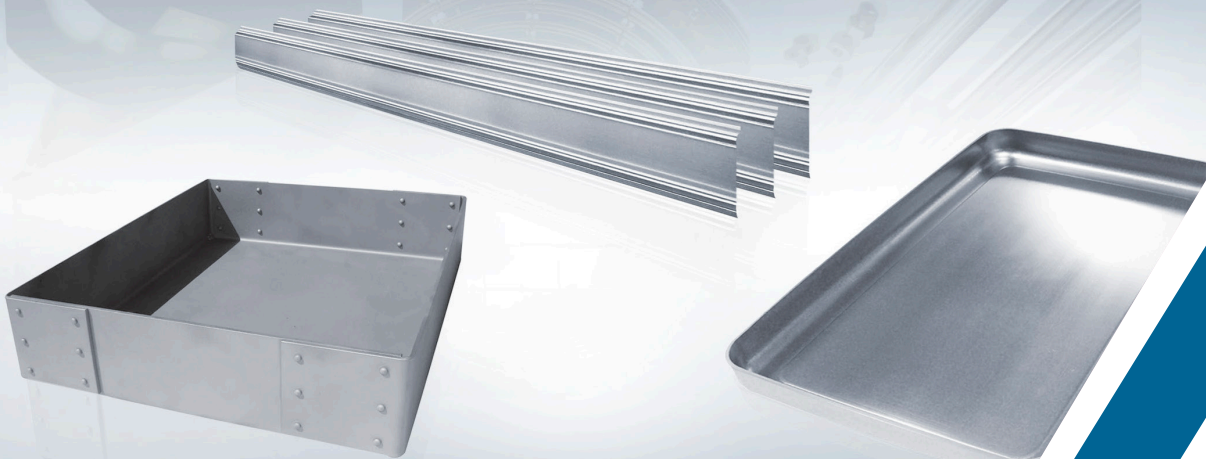
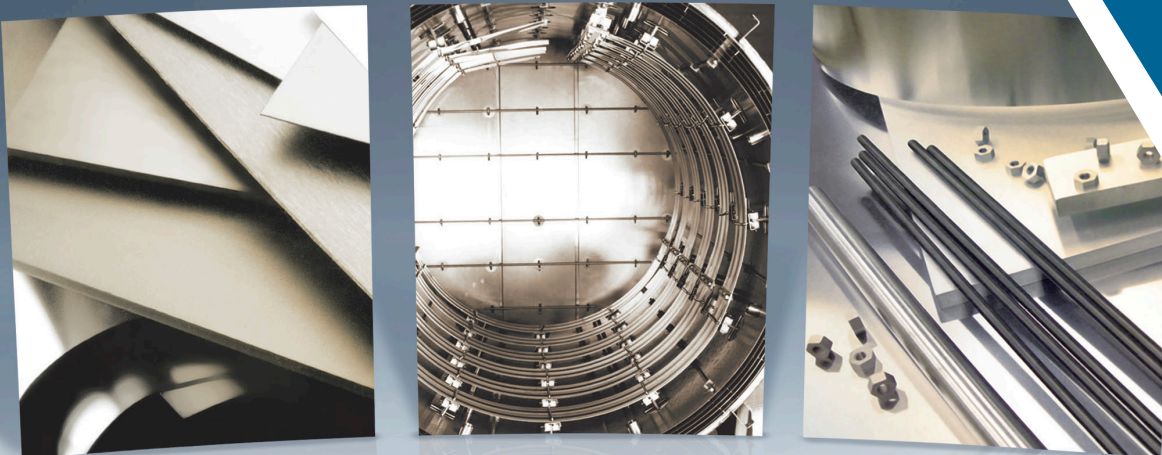


HIGH PERFORMANCE SOLUTIONS WITH MOLA ALLOYS



OUR COMMITMENT TO ENGINEERING EXCELLENCE

Elmet Technologies delivers superior quality with material consistency and product reliability. Elmet Technologies achieves world class quality through continuous research of new products, development of engineering solutions, and applying them in Elmet Technologies' manufacturing environment to deliver premium products for the most challenging applications.

Nearly 100 years of powder metallurgical experience is the cornerstone of Elmet Technologies' success in producing advanced technology metals for fast growing industries including aerospace, chemical processing, electronics, industrial, medical, and energy. As one of the world's leading suppliers of molybdenum, tungsten, tantalum, niobium, and their alloys, Elmet Technologies is at the forefront of creating solutions with next-generation materials and fabricates engineered components for a diverse spectrum of markets.

- > Product Quality and Service
- > Research and Development
- > Manufacturing Excellence
- > Reclamation and Recycling



STRATEGIC ADVANTAGES OF WORKING WITH ELMET TECHNOLOGIES

Elmet Technologies understands market trends and the latest cutting-edge technologies providing us the opportunity to create value-added solutions for complex applications. In addition, our robust and sustainable vertically integrated supply chain enables us to deliver high performance materials and products seamlessly to the marketplace.

A recognized leader in refractory metal technology, Elmet Technologies' knowledge and technical expertise benefit customers through joint collaborations with our dedicated team of research engineers. This collaborative effort facilitates new and improved product designs through a study of the product's life-cycle. Extensive in-house state-of-the-art laboratory facilities with the latest in analytical tools, testing equipment, modeling and simulation software assist engineers in evaluating product performance. Innovative material solutions provide texture control thus enhancing the uniformity and performance consistency.

With sales locations worldwide including Asia, and the Americas, Elmet Technologies offers exceptional customer care with local sales and technical support.

RECRYSTALLIZATION AND HIGH-TEMPERATURE WARPAGE RESISTANCE

Molybdenum-lanthana (MoLa) alloys are one type of oxide-dispersion strengthened (ODS) molybdenum containing molybdenum and a very fine array of lanthanum trioxide particles. This combination creates extraordinary characteristics of the material, which demonstrate resistance to recrystallization as well as high-temperature warpage. Molybdenum-lanthana is an ideal material for applications requiring dimensional stability and strength at temperatures above the capabilities of either pure molybdenum or molybdenum TZM alloy.

Elmet Technologies manufactures MoLa alloys in three levels of doping with lanthanum trioxide: 0.3 weight %, 0.6 weight % and 1.1 weight %. The trioxide particles stabilize the grain structure of the material creating very beneficial high temperature performance. The unique Elmet Technologies doping process of introducing the oxide particles to the molybdenum matrix is key to the excellent properties obtained, and differentiates Elmet Technologies from other manufacturers of similar materials. In addition, the doping process maximizes the homogeneity of the lanthanum oxide dispersed in the molybdenum matrix.

Elmet Technologies' MoLa alloy products are used in high temperature furnace and heat treating applications:

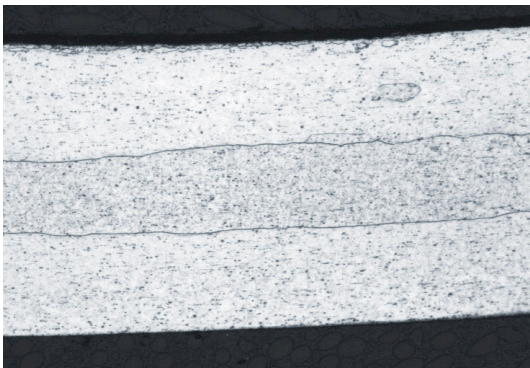
> [Medical devices](#)>

> [Aircraft and Aerospace components](#)

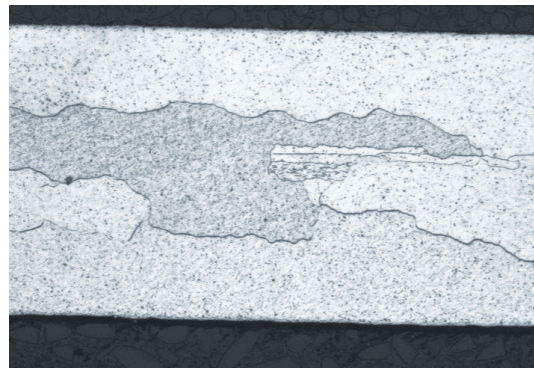
> [Nuclear Fuel Pellet production](#)

> [High Pulse Magnet Research](#)

Microstructures of recrystallized 0.2 mm thick MoLa sheet



Longitudinal direction



Transverse direction

ADVANTAGES OF ELMET TECHNOLOGIES' MOLA ALLOYS

MoLa alloys have great formability at all grade levels when compared to pure molybdenum in the same condition. Pure molybdenum recrystallizes at approximately 1200 °C and becomes very brittle with less than 1% elongation, which makes it not formable in this condition.

MoLa alloys in plate and sheet forms perform better than pure molybdenum and TZM for high temperature applications. That is above 1100 °C for molybdenum and above 1500 °C for TZM. The maximum advisable temperature for MoLa is 1900 °C, due to the release of lanthana particles from the surface at higher than 1900 °C temperature.

The "best value" MoLa alloy is the one containing 0.6 wt % lanthana. It exhibits the best combination of properties. Low lanthana MoLa alloy is an equivalent substitute for pure Mo in the temperature range of 1100 °C – 1900 °C. The advantages of high lanthana MoLa, like superior creep resistance, are only realized, if the material is recrystallized prior to use at high temperatures.

CUSTOMERS BENEFIT FROM MULTIPLE GRADES OF MOLA ALLOYS OFFERED BY ELMET TECHNOLOGIES

Elmet Technologies offers three grades of molybdenum-lanthana with specific characteristics that benefit customers depending on their application.

0.3 wt. % Lanthana

- > Considered a substitute for pure molybdenum, but with longer life due to its increased creep resistance
- > High malleability of thin sheets; the bendability is identical regardless, if bending is done in longitudinal or transverse directions

0.6 wt. % Lanthana

- > Standard level of doping for the furnace industry, most popular
- > Combines the widely accepted high temperature strength with creep resistance – considered the "best value" material
- > High malleability of thin sheets; the bendability is identical regardless, if bending is done in longitudinal or transverse directions

1.1 wt. % Lanthana

- > Strong warpage-resistance
- > High strength properties
- > Exhibits the highest creep resistance of all offered grades
- > Applications for formed parts require recrystallizing anneal cycle

MOLA ALLOY PRODUCTS FOR THE FURNACE INDUSTRY

From flat plate and sheet to complex assembled products, Elmet Technologies can provide a wide range of products to fit your specific application. Elmet Technologies Solutions' MoLa material is available in sheet, plate (up to 0.300" thick), rod, and bar. Dimensional tolerances are identical to those for our molybdenum and TZM products in the same forms.

PRODUCT	THICKNESS INCHES	MM
Plate ¹	0.05 to 0.125	1.3 to 3.2
Sheet ¹	0.008 to 0.047	0.2 to 1.2
Carrier slabs	0.65 to 1	16 to 25
Reduction and sintering boats	0.06 to 0.100	1.5 to 2.5
Furnace racks	0.100 to 0.150	2.5 to 3.5
Trays ²	0.025 to 0.047	0.6 to 1.2
Heat shields (Top and Bottom)	0.010 to 0.020	0.25 to 0.5
Heating elements ³ and strips	0.020 to 0.040	0.5 to 1
Heat sinks	less than 0.010	less than 0.25

1) Dimensional tolerance is identical to our molybdenum and TZM mill products in the same forms.

2) Trays are similar to boats, but less height and can be made by folding without riveting or deep drawing and stamping.

3) We recommend rectilinear heating elements due to their lower power consumption versus round.

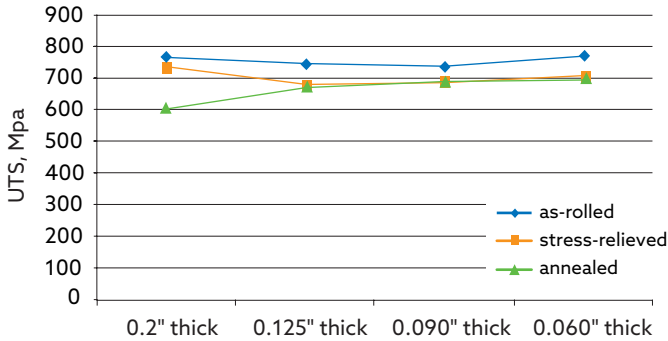


MECHANICAL AND PHYSICAL PROPERTIES

Strength

MoLa alloy at a level of 1.1% lanthana retains five times the strength of pure molybdenum at 1500 °C and exceeds the strength of the TZM alloy above 1400 °C.

Strength Development in Thick Gauge 0.6 % MoLa



Room temperature strength of thick gauge MoLa sheet remains almost unchanged over a wide range of thicknesses.

Physical Properties of Tungsten KU-1000 Powder

THICKNESS INCHES	MM	DIRECTION	AS-ROLLED	STRESS-RELIEVED	ANNEALED
0.2	5.1	L	14.46	23.12	27.35
		T	0.86	5.33	0.4
0.125	3.2	L	16.04	22.54	27.66
		T	1.26	2.45	5.3
0.09	2.3	L	5.87	17.83	20.53
		T	17.74	20.5	21.55
0.06	1.5	L	16.24	18.17	22.11
		T	15.89	20.95	21.55

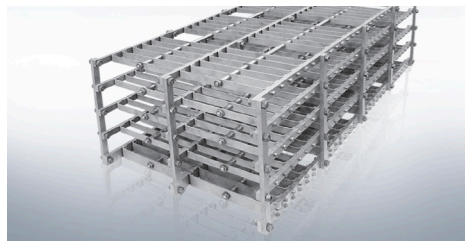
L = Longitudinal
T = Transverse

Elongation values are affected by the amount of cross-rolling. Directional isotropy can be achieved, if dimensional requirements from customer allow for it.

Creep and Stress-Rupture

The creep rate of 1.1 % MoLa at 1800 °C is two orders of magnitude lower than pure molybdenum tested at 1200 °C, and has about one order of magnitude lower creep rate than TZM molybdenum alloy tested at 1650 °C. This is an extraordinary property of 1.1 % MoLa alloy.

For applications where high-temperature dimensional stability and sag resistance is paramount, for example, setter tiles, sintering boats, and furnace elements, MoLa alloys provide superior performance.

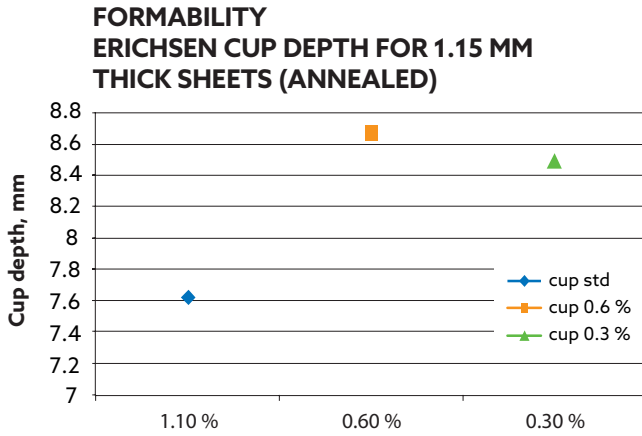


DRAWABILITY AND FORMABILITY

Formability of MoLa Sheets

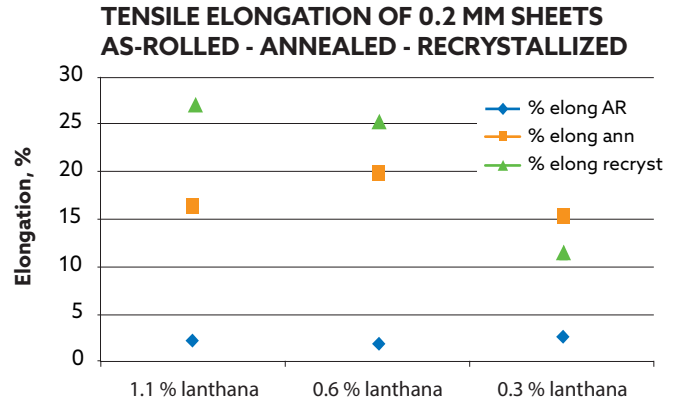
Elmet Technologies has tested formability and deep drawability of 0.047" (1.5 mm), 0.020" (0.5mm) and 0.008" (0.2mm) thick MoLa sheets of all offered grades.

Thick Gauge MoLa Sheets

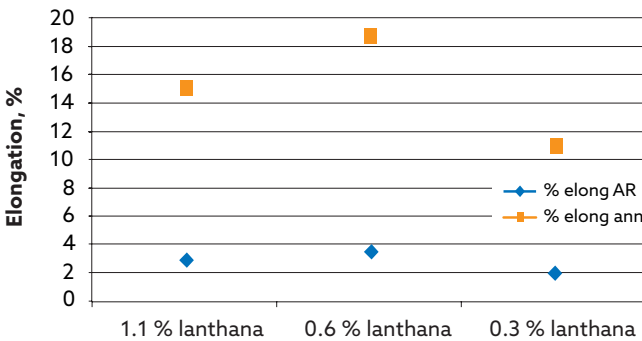


1.15 mm or 0.047" thick MoLa sheets exhibit excellent formability and deep drawability with the best formability being the 0.6 % MoLa.

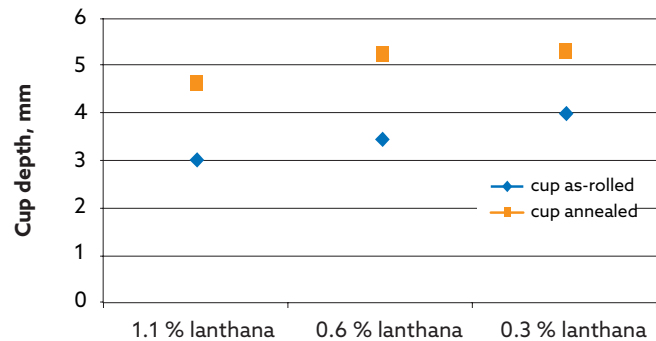
Thin Gauge MoLa Sheets



TENSILE ELONGATION OF 0.5 MM SHEETS AS-ROLLED VS. ANNEALED



DEEP DRAWABILITY/FORMABILITY ERICHSEN CUP VALUES OF 0.2 MM THICK SHEETS AS-ROLLED VS. ANNEALED



Recrystallized 1.1 % and 0.6 % MoLa sheets are more ductile than annealed. In fact, they are very ductile (elongation is greater than 25 %). Recrystallized 0.3 % MoLa sheet is less ductile than annealed.



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