

The PI-KEM logo consists of the text "PI-KEM" in a bold, white, sans-serif font, centered within a blue square. Above and below the text are two thin, white, curved lines that form a partial circle.

PI-KEM

UK & European
Distributor

PRODUCT CATALOG

Optical Coatings from Concept to Commercialization (OC³)



About US



Since 1989, LTS Research Laboratories Inc., has been a leader in the manufacture and supply of high purity chemicals to the optical, electronics, and semiconductor industries. We started in 1992 with the discovery of the Direct Fluorination Method (DFM), used originally to purify Scandium oxide. The DFM process was applied to a variety of fluoride materials which found immediate success in UV-IR applications. In 1992, the DFM process was also applied to synthesize YBC, our Thorium fluoride replacement flagship materials for MIL-grade optics in DUV and IR-FIR spectra CO₂ laser applications. Today, our YBC materials are pivotal in missile guidance systems and are utilized by militaries around the globe.


In 1998, LTS commercialized extremely low Zirconia-containing Hafnium oxide products for excimer laser applications. Synthesized via liquid phase formation (LPF), our ultra-high purity Hafnia exhibits the highest refractive index and minimum absorption at 224 nm, as well as the highest laser-induced damage thresholds (LIDT) deposited for 248 nm coatings.

In 1998, LTS introduced high purity Ta₂O₅ with controlled iron impurity content, ideal to produce EDFA switches which revolutionized commercial internet gears for communication companies.

In 2003, in collaboration with Korean electronics companies, LTS R&Ded the first generation Indium Gallium Zinc Oxide (IGZO) chemicals for high-density thin film transistor materials. Currently, IGZO is used worldwide by the microelectronics industry as well for case studies in universities and research centers. IGZO and other similarly performing low cost transparent conductive oxides (IZO, ITZO, ZTO, GTZO, etc.) have effectively replaced ITO and AZO.

Presently, LTS is engaged in the research, development, and production of next generation lithium-ion battery chemicals, high purity halides, and specialty suboxides. Furthermore, LTS has expanded its wings in the field of analytical services, including but not limited to, atomic absorption, SEM, XRD, GC, and GCMS which are aimed at providing technical information about products both internal and external.

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FLUORIDES



UV/DUV Fluoride

Aluminum Fluoride (AlF_3)
Cryolite (Na_3AlF_6)
Gadolinium Fluoride (GdF_3)
Lanthanum Fluoride (LaF_3)
Neodymium Magnesium
Fluoride (NdMgF_4)

High Index Mid-Range Coatings

Holmium Neodymium Fluoride
(HoNdF_4)
Lithium Fluoride (LiF)
Lithium Scandium Fluoride
(LiScF_4)
Scandium Fluoride (ScF_3)

Mid NIR High Index Fluorides

Cerium Fluoride (CeF_3)
Dysprosium Fluoride (DyF_3)
Ytterbium Fluoride (YbF_3)
Yttrium Fluoride (YF_3)

Thorium Fluoride Replacement Solutions

YBC-375
YBC-905
YBC-907



Dysprosium Fluoride



Yttrium Fluoride

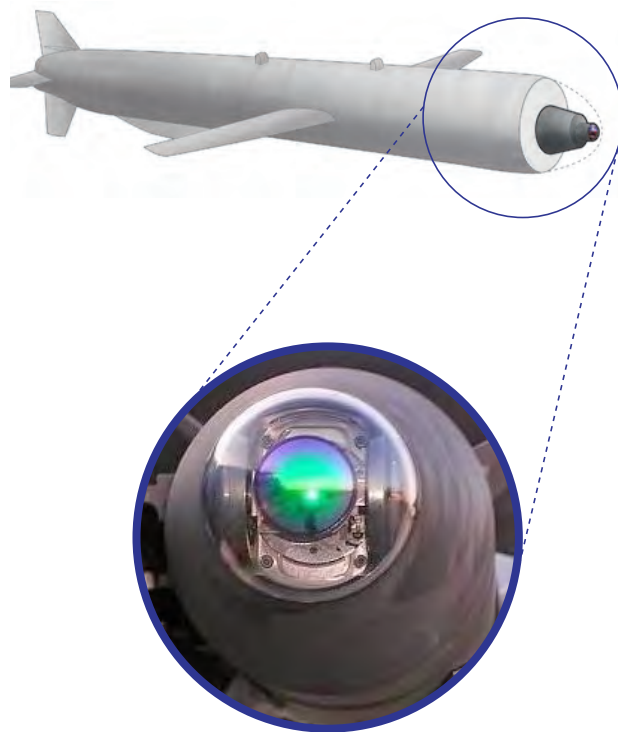
Since 1992, LTS has been producing MIL-SPEC compliant fluoride materials using the Direct Fluorination Method (DFM). DFM is a 2-step process where an oxide is first reacted with fluorine vapor, and then undergoes a secondary fluorination during melting.

Unlike conventional hydrofluoric (HF) acid precipitated fluorides, the DFM process effectively removes contaminants as well as trapped gases. DFM fluorides are mechanically stable, fully fluorinated, and completely outgassed. The result is a significantly purer material that undergoes cleaner, quicker deposition and ultimately provides a better optical coating.

YBC DFM is the premier low index Thorium fluoride (ThF_4) replacement material. Transparent in the NIR to IR spectrum, YBCs are recommended for multilayer coatings for applications including AR, bandpass, and dichroic filters. They are primarily used in CO_2 laser optics.

Deposition Method:

Like other DFM materials, no outgassing occurs during deposition and chamber preparation times can be reduced up to 2/3 compared to the competition. Multilayer coatings of YBC have an amorphous microstructure and their films are relatively soft. Furthermore, films are very durable, chemically stable, and exhibit low stress and exceptional substrate adhesion.



YBC is typically deposited using electron beam physical vapor deposition at temperatures of 1,250-1,500°C; molybdenum, tantalum, or platinum boats should be used. The recommended substrate temperature is 250°C, and evaporating chamber pressures should be less than 10 mbar to achieve a deposition rate of 10 Å/sec.

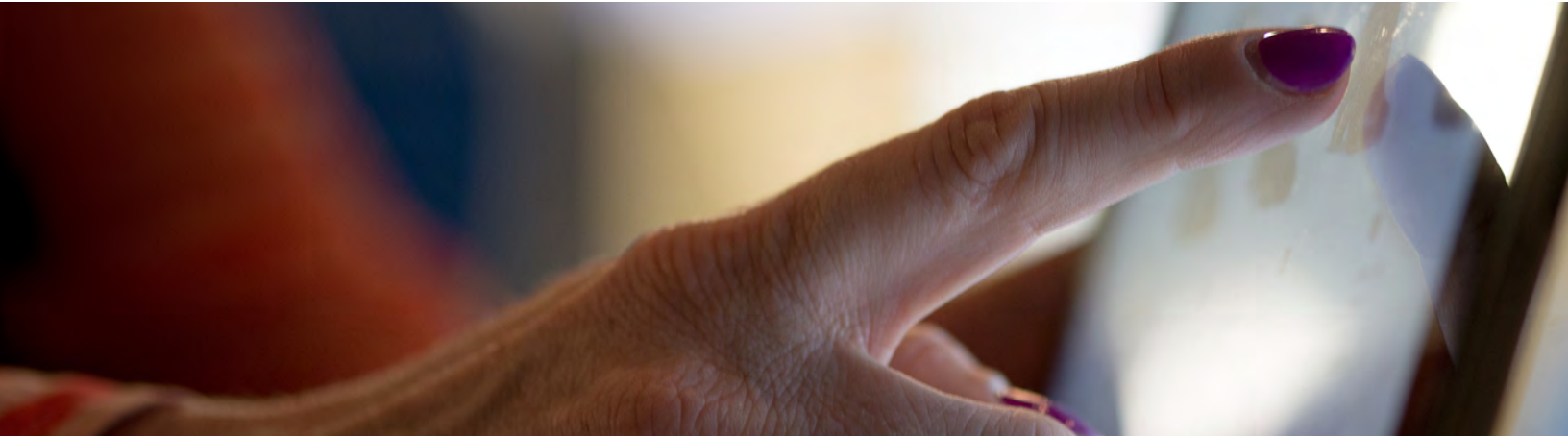
YBC-375: Optimized for easy deposition onto Ge and ZnSe. Performs well for the majority of all IR and CO_2 laser applications.

YBC-905: Forms highly durable coatings, but cannot be used in moist environments or applications around 3.8 and 5.6 microns due to elevated absorptions

YBC-907: Exceptionally low absorption in the NIR/IR region. Mildly toxic but outperforms radioactive Thorium Fluoride as the superior material for CO_2 laser component films.



TRANSPARENT CONDUCTIVE OXIDES



Transparent conductive oxides (TCOs) are electrically conductive materials with low absorption and high transmittance of visible light. TCOs are utilized in several applications including flat panel displays, thin film solar cells, light emitting diodes (LEDs), opto-electrical interfaces, touchscreens, and automobile window de-icers/de-foggers. Indium Tin Oxide (ITO) has been the most widely used TCO due its low resistivity ($\sim 10^{-4} \Omega\text{-cm}$) and high transparency in the visible spectrum. Recently, Aluminum-doped Zinc Oxide (AZO) and Indium-doped Cadmium Oxide have emerged as more economical alternatives to ITO.

LTS pioneered the research and development of both standard as well as custom designed TCOs catering to the demands of the photovoltaic industry. Since 2006, LTS has contributed to the innovation and commercialization of TCOs with materials including, but not limited to:

- Aluminum Zinc Oxide (AZO)
- Indium Gallium Oxide (IGO)
- Indium Gallium Zinc Oxide (IGZO)
- Indium Tin Oxide (ITO)
- Indium Tin Zirconium Oxide (ITZO)
- Indium Zinc Oxide (IZO)
- Tin Oxide (SnO)
- Zinc Tin Oxide (ZTO)

We also offer customized products and compositions for R&D projects.



ITZO Granules

SEMICONDUCTING CHALCOGENIDE GLASSES

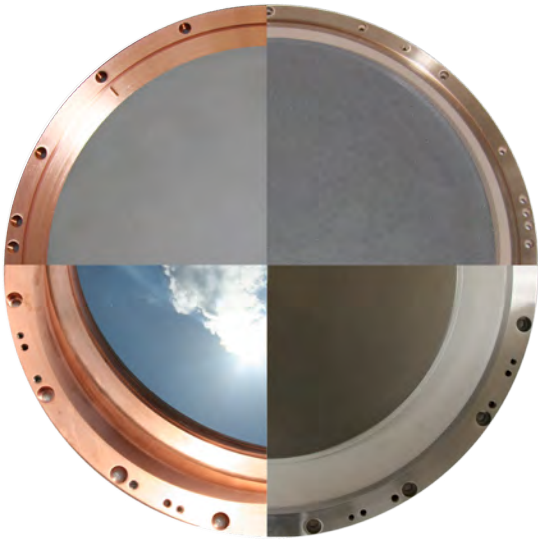
Semiconducting chalcogenide glasses, first produced in the late 1950's, are classified as covalently bonded network solids that act as a single molecular complex. They exhibit a variety of unique thermal, optical, and electrical properties, most notably for the ability to undergo high speed phase transitions.

With ultrafast broadband response times, tunable third order nonlinear refractive indices, and specific optical band gap energies, Chalcogenide glasses are promising candidates for modern technological applications such as IR detectors, lenses, optical fibers, and photonic integrated circuits, as well as emergent Phase-change Random Access Memory (PCRAM).

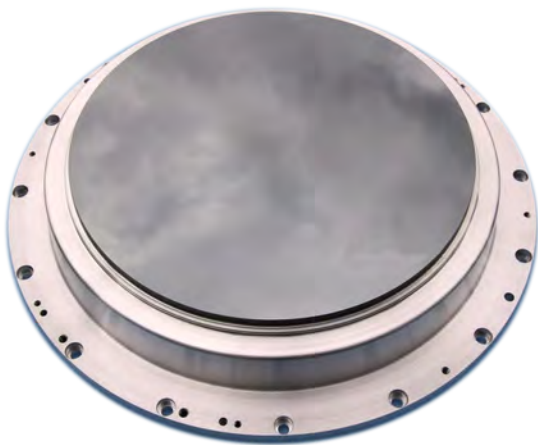
In PCRAM applications, the glass is subjected to localized electric current pulses which trigger the thermally driven phase transformations from an amorphous to crystalline state; this process is reversed by a brief exposure to heat followed by rapid quenching. A readout is performed utilizing the differences in conductivity between the two phases. Cycles take only nanoseconds in application.

The following materials are currently made in 125 mm and up to 440 mm diameter sizes for ULVAC, VEECO, and Anelva systems. Custom compositions and the addition of dopants are being developed to enhance thermal and electrical properties.

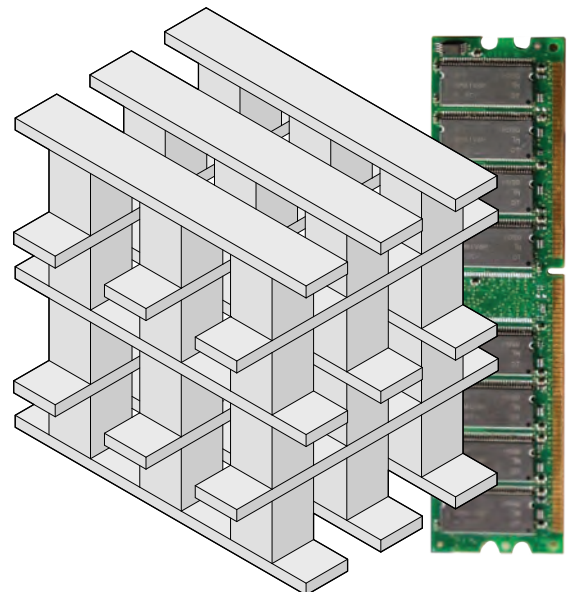
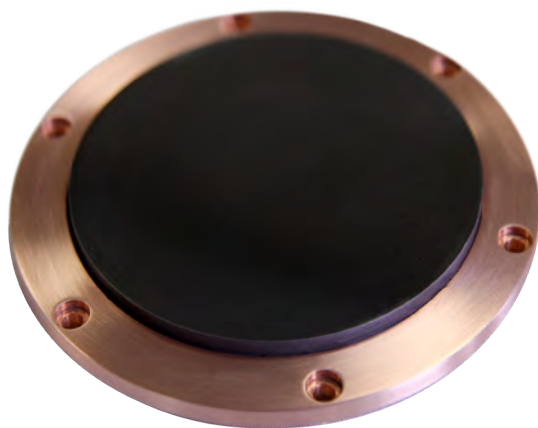
Germanium Antimony Telluride (GST)
Selenium Arsenic Germanium (SAG)
Germanium Arsenic Selenium Telluride (GAST)
Tellurium Arsenic Germanium Silicon (TAGS)



GAST 440 mm Ulvac target



SAG 125 mm Ulvac target



HIGH-PURITY HAFNIUM METAL



Hafnium Insert



Hafnium Turnings



Hafnium Pellets

Hafnium is a lustrous, ductile metal conventionally used in nuclear control rods due to its excellent neutron capture cross-sectional properties. It is also used in the recrystallization of tungsten filaments, removal of trace gases in vacuum tubes, and as an alloying agent in select metals. Hafnium naturally occurs with zirconium in minerals, thus requiring separation for practical application. However, due to their nearly identical chemical properties this process proves difficult.

LTS offers high purity hafnium metal with exceptionally low zirconium content. As compared to the conventional liquid-liquid separation followed by reduction, our hafnium is purified and outgassed during zone refining (via e-beam). We offer hafnium in several forms including sputtering targets, pellets, and inserts.

Product Data:

Purity: 99.9 - 99.95%

(Zr<2000 ppm, Zr<1200 ppm, Zr<800 ppm available)

Melting Point: 2227 °C

Clockwise from the top:

Hafnium Oxide Target

Hafnium Oxide/Silicon Dioxide Assembly for
14" VEECO systems

Hafnium Metal Targets



HAFNIUM OXIDE



Hafnium Suboxide Insert



Hafnium Suboxide Insert with Crucible Liner



Hafnium Oxide Tablets

Hafnium oxide (HfO_2) is used for coatings in the near-UV (230 nm) to IR (8,000 nm) spectrum, due to its high-index and low-absorption properties. Typically deposited as multilayered coatings with silicon dioxide (SiO_2), hafnium oxide is proven for a wide range of applications such as IR mirror coatings, emitter wire coatings, achromatic beam splitting, and for protective, polarizing and dielectric coatings.

LTS offers ultra-high purity hafnium oxide products with unique characteristics. Our hafnium oxide has the highest index and lowest absorption at 224 nm, is completely outgassed, and only requires 1/3rd the preconditioning time before deposition compared to other commercially available hafnium oxide products. Additionally, our hafnium oxide exhibits the highest Laser-Induced Damage Threshold (LIDT) qualifying it for excimer laser applications. Our wide array of hafnium oxide products includes E-beam reduced hafnium suboxide in pellets, pieces, disks, and pre-melted conical inserts in various sizes for Telemark and Temescal crucible liners.

Product Data:

Purity: 99.95%-99.99% (Zr<2500 ppm, Zr<1700 ppm, Zr<1200 ppm, Zr<200 ppm available)

Melting Point: 2880 °C

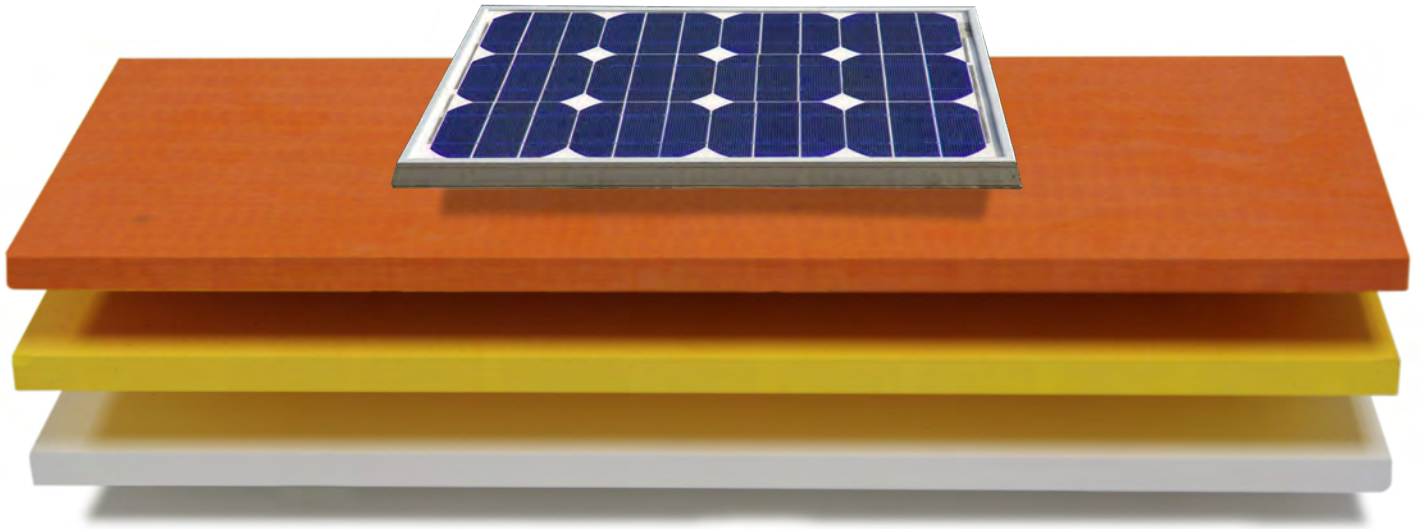
Evaporation Temperature: 2300 - 2500 °C

Transmission Range: 230 nm - 8,000 nm

Refractive Index:

230 nm	2.30
250 nm	2.30
300 nm	2.10
500 nm	2.00
600 nm	1.98
700 nm	1.98
900 nm	1.97
2,000 nm	1.94
8,000 nm	1.88

PHOTOVOLTAIC CHEMICALS



The push for clean, renewable energy requires advanced photovoltaic systems with increased efficiencies and lower costs.

Currently, amorphous and crystalline silicon wafers are the most extensively used solar cell substrates, however, novel thin film technologies are being developed to replace existing silicon systems.

In thin-film solar cells, layers of semiconducting materials are applied to a solid substrate. When compared to silicon wafers, these thin films require less material, and therefore substantially diminish production costs.

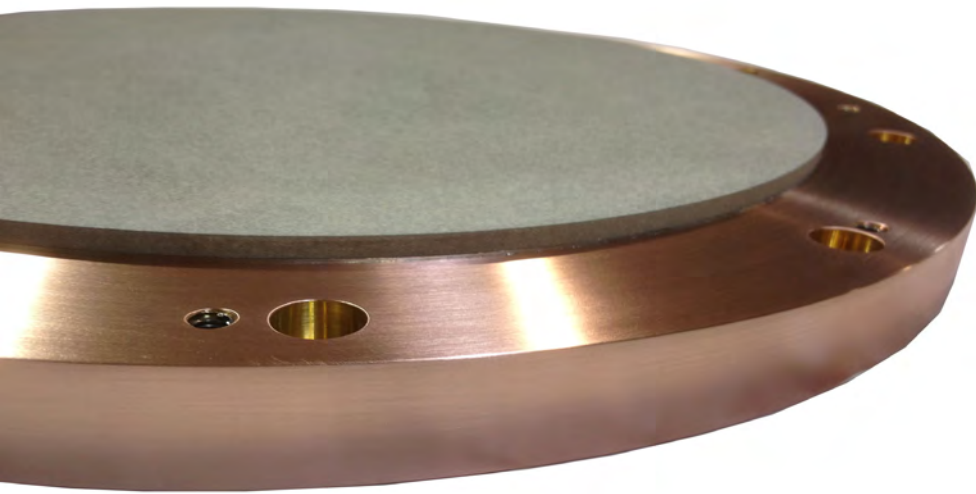
LTS Research Laboratories, Inc. remains on the cutting edge of photovoltaic chemical development via strict adherence to client requirements - size, shape, purity, phase and composition.

Product List:

- Cadmium Arsenide (Cd_3As_2)
- Cadmium Oxide (CdO)
- Cadmium Oxide/Tin Oxide (CdO/SnO)
- Cadmium Selenide (CdSe)
- Cadmium Stannate (Cd_2SnO_4)
- Cadmium Sulfide (CdS)
- Cadmium Telluride (CdTe)
- Cadmium Tungstate (CdWO_4)
- Cadmium Zinc Telluride (CdZnTe)
- Copper Indium Gallium Selenide (CuInGaSe)
- Copper Indium Selenide (CuInSe)
- Copper Zinc Tin Selenide (CuZnSnSe)
- Copper Zinc Tin Sulfide (CuZnSnS)
- Gallium Arsenide (GaAs)
- Indium Phosphide (InP)



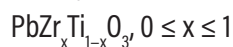
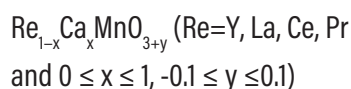
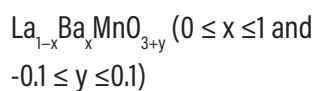
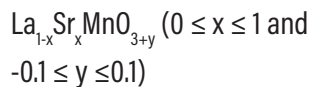
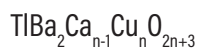
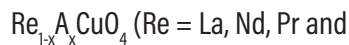
PEROVSKITES



Niobium-doped Lead Zirconium Titanate

Perovskites may be structured in layers, with the base ABO_3 structure separated by thin sheets of intrusive materials. Ruddlesden-Popper (RP) phases have general formula $A_{n-1}A'_2B_nX_{3n+1}'$, where A and A' represent alkali, alkaline earth, or rare earth metal, while B refers to transition metal. Aurivillius phases consist of n perovskite-like layers $(A_{n-1}B_nO_{3n+1})^{2-}$ sandwiched between bismuth-oxygen sheets $(Bi_2O_2)^{2+}$.

LTS Perovskites



Application

Superconductor

Colossal Magnetoresistance

Piezoelectric and ferroelectric perovskites

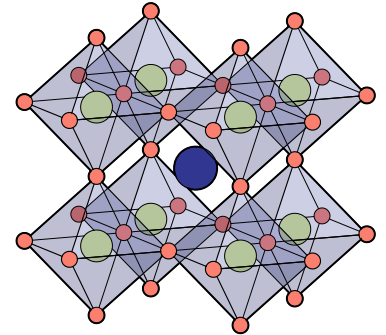
Properties

High temperature superconductivity

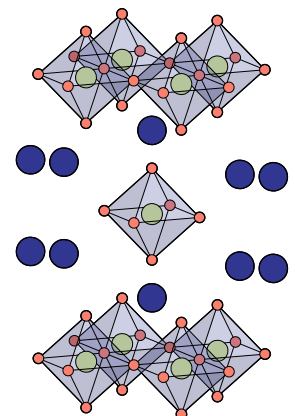
Variety of resistances depending on altering magnetic fields and temperatures

High voltage and power sources; Sensors and actuators; Vibration dampers; Frequency standards and hybrid cells

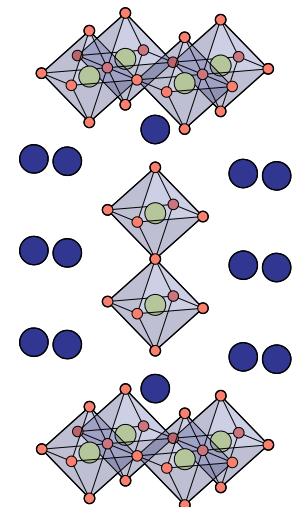
Ruddlesden-Popper Phases $AO(ABO_3)_n$



$n=2$
 $(AO)(ABO_3)_3$



$n=1$
 $(AO)(ABO_3)$



$n=2$
 $(AO)(ABO_3)_2$

LITHIUM-ION BATTERY CHEMICALS



LTS Research Laboratories, Inc. is fueling the renewable, clean energy movement with the R&D of superior solid state electrolyte battery materials.

When evaluating battery materials, the following factors need to be considered:

Energy Density: the amount of energy stored per unit weight or sometimes per volume

Specific Power: the speed you can deliver that energy

Lifespan: number of charge-discharge cycles sustained before failure

Safety: given the high reactivity of many battery chemicals

Durability: against high and low temperatures and idle time

Recharge Rate

Cost

Product Properties

LiCoO_2 :	High energy density, low power
LiMn_2O_4 :	High power, low energy density
$\text{Li}(\text{Ni},\text{Mn},\text{Co})\text{O}_2$:	Combines the properties of the above three for increased energy density, power, and stability
$\text{Li}(\text{Ni},\text{Co},\text{Al})\text{O}_2$:	Similar to above, but increased more cost and safety concerns
LiFePO_4 :	Long lifespan, consistent discharge, safe, low energy density
LiNiO_2 :	High energy density, low stability
$\text{Li}_4\text{Ti}_5\text{O}_{14}$:	Safe, long lifespan and temperature range, low energy density, more costly
C (Graphite):	Typically used as the anode to any of the above, or as the cathode to $\text{Li}_4\text{Ti}_5\text{O}_{14}$



Our new Lithium electrolytes:

Lithium Germanium Phosphorus Sulfide (LiGePS)
Lithium Germanium Phosphorus Sulfur Chloride ($\text{Li}_{10}\text{GeP}_2\text{S}_{12}\text{Cl}$)
Lithium Phosphorus Sulfide (Li_3PS_4)
Lithium Phosphorus Sulfur Bromide ($\text{Li}_6\text{PS}_5\text{Br}$)
Lithium Phosphorus Sulfur Chloride ($\text{Li}_6\text{PS}_5\text{Cl}$)
Lithium Phosphorus Sulfur Iodide ($\text{Li}_6\text{PS}_5\text{I}$)
Lithium Phosphorus Tellurium Bromide ($\text{Li}_6\text{PTe}_5\text{Br}$)
Lithium Phosphorus Tellurium Chloride ($\text{Li}_6\text{PTe}_5\text{Cl}$)
Lithium Phosphorus Tellurium Iodide ($\text{Li}_6\text{PTe}_5\text{I}$)

PRECIOUS METALS & ALLOYS

LTS produces an array of precious metal alloys containing platinum, silver, ruthenium, gold, palladium, etc. Using E-beam melting, we can provide small quantities for laboratory scale requirements (1 to 25 g) as well as larger quantities (>1 kg) for industrial applications.



Gold Alloys

Beryllium Gold (Be/Au)
Boron Gold (B/Au)
Germanium Gold (Ge/Au)
Palladium Gold (Pd/Au)
Silver Gold (Ag/Au)
Tin Gold (Sn/Au)

Iridium Alloys

Manganese Iridium (Mn/Ir)
Platinum Iridium (Pt/Ir)

Palladium Alloys

Aluminum Palladium (Al/Pd)
Cerium Palladium (Ce/Pd)
Cobalt Palladium (Co/Pd)
Gold Palladium (Au/Pd)
Nickel Palladium (Ni/Pd)
Silver Copper Palladium (Ag/Cu/Pd)
Zinc Palladium (Zn/Pd)

Platinum Alloys

Cobalt Platinum (Co/Pt)
Graphite Platinum (C/Pt)
Iron Platinum (Fe/Pt)
Nickel Platinum (Ni/Pt)

Ruthenium Alloys

Aluminum Ruthenium (Al/Ru)
Chromium Ruthenium (Cr/Ru)
Molybdenum Ruthenium (Mo/Ru)
Tantalum Ruthenium (Ta/Ru)

Silver Alloys

Aluminum Silver (Al/Ag)
Bismuth Silver (Bi/Ag)
Chromium Silver (Cr/Ag)
Copper Silver (Cu/Ag)
Graphite Silver (C/Ag)
Magnesium Silver (Mg/Ag)
Palladium Copper Silver (Pd/Cu/Ag)
Rhenium Silver (Re/Ag)
Ruthenium Silver (Ru/Ag)
Tin Silver (Sn/Ag)
Titanium Silver (Ti/Ag)

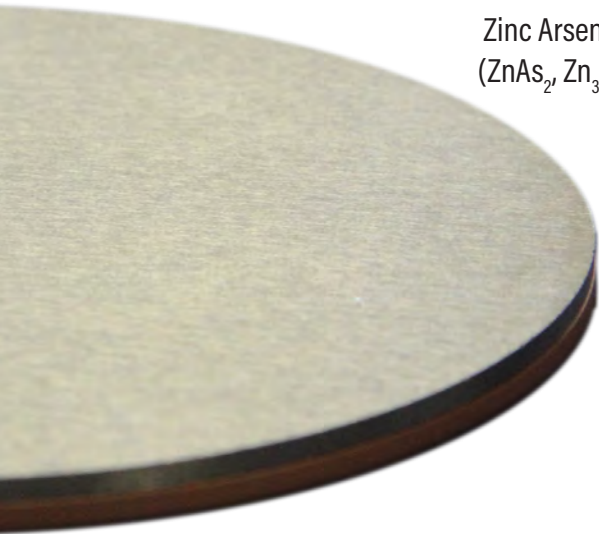
SEMICONDUCTOR-GRADE MATERIALS

LTS manufactures an entire series of Sulfides, Arsenides, Selenides, Germanides, and other intermetallics for MEMS and semiconductor applications, integrated circuit, and flat panel display technologies.

LTS employs an array of vacuum furnaces from 300-500 L for the purification and custom alloying of semiconductor compounds in the form of evaporation pieces and sputtering targets.



Germanides	Arsenides	Tellurides	Selenides	Sulfides
Copper Germanium (CuGe)	Gallium Arsenide (GaAs)	Antimony Telluride (Sb ₂ Te, Sb ₂ Te ₃)	Antimony Selenide (Sb ₂ Se ₃)	Antimony Sulfide (Sb ₂ S ₃)
Germanium Antimony (GeSb)	Gallium Arsenide Titanium (GaAsTi)	Arsenic Telluride (As ₂ Te ₃)	Arsenic Selenide (AsSe, As ₂ Se ₃)	Arsenic Sulfide (As ₂ S ₃)
Gold Germanium (AuGe)	Indium Arsenide (InAs)	Bismuth Telluride (Bi ₂ Te ₃)	Bismuth Selenide (Bi ₂ Se ₃)	Bismuth Sulfide (Bi ₂ S ₃)
Silicon Germanium (SiGe)	Tin Arsenide (SnAs)	Copper Telluride (CuTe, CuTe ₂)	Copper Germanium Selenide (CuGeSe)	Chromium Sulfide (Cr ₂ S ₃)
	Zinc Arsenide (ZnAs ₂ , Zn ₃ As ₂)	Gallium Telluride (GaTe, Ga ₂ Te ₃)	Copper Indium Selenide (CIGS)	Copper Antimony Sulfide (CuSbS)
		Germanium Telluride (GeTe, GeTe ₂)	Indium Selenide (In ₂ Se ₃)	Copper Germanium Sulfide (Cu ₂ GeS ₃)
		Mercury Telluride (HgTe)	Lead Selenide (PbSe)	Copper Sulfide (Cu ₂ S)
		Tungsten Telluride (WTe ₂)	Tin Selenide (SnSe, SnSe ₂)	Copper Zinc Tin Sulfide (Cu ₂ ZnSnS ₄)



HIGH PURITY HALIDES

Form

All of our high purity halide salts are available in ultra-dry and anhydrous forms and are packed in argon purged ampoules to prevent hydration. They are typically in the form of -10 mesh beads and -100 mesh powder. Typical purities are +99.999%

Applications

These halides are used as chemical reagents and catalysts in chemical synthesis. Some are used in photographic and x-ray films, optical polarizing films for LCD displays, flame retardants, and disinfectants and biocides for water and agriculture.

Our high purity material is suitable for use in MBE deposition systems.



Iodides	Chlorides	Bromides
Aluminum Iodide (AlI_3)	Aluminum Chloride (AlCl_3)	Aluminum Bromide (AlBr_3)
Barium Iodide (BaI_2)	Bismuth Chloride (BiCl_3)	Barium Bromide (BaBr_2)
Bismuth Iodide (BiI_3)	Chromium Chloride (CrCl_2)	Bismuth Bromide (BiBr_2)
Calcium Iodide (CaI_2)	Copper Chloride (CuCl)	Cobalt Bromide (CoBr_2)
Cobalt Iodide (CoI_2)	Europium Chloride (EuCl_3)	Gadolinium Bromide (GdBr_3)
Cesium Iodide (CsI)	Iron Chloride (FeCl_2)	Potassium Bromide (KBr)
Europium Iodide (EuI_2)	Gallium Chloride (GaCl_3)	Lead Bromide (PbBr_2)
Lithium Iodide (LiI)	Gadolinium Chloride (GdCl_3)	Zirconium Bromide (ZrBr_2)
Gallium Iodide (GaI_3)	Sodium Chloride (NaCl)	
Gadolinium Iodide (GdI_3)	Antimony Chloride (SbCl_3)	
Indium Iodide (InI_3)	Samarium Chloride (SmCl_3)	
Potassium Iodide (KI)	Terbium Chloride (TbCl_3)	
Lanthanum Iodide (LaI_3)	Tungsten Chloride (WCl_6)	
Lutetium Iodide (LuI_3)		
Magnesium Iodide (MgI_2)		
Lead Iodide (PbI_2)		
Antimony Iodide (SbI_3)		
Samarium Iodide (SmI_2)		
Ytterbium Iodide (YbI_2)		



REFRACTORY ALLOYS & CERAMICS

Nitrides

Aluminum Nitride (AlN)
Boron Nitride (BN)
Gallium Nitride (GaN)
Indium Nitride (InN)
Silicon Nitride (Si₃N₄)
Tantalum Nitride (TaN)
Titanium Nitride (TiN)

Carbides

Molybdenum Carbide (Mo₂C)
Niobium Carbide (NbC)
Silicon Carbide (SiC)
Tantalum Carbide (TaC)
Titanium Carbide (TiC)
Tungsten Carbide (WC)

Silicides

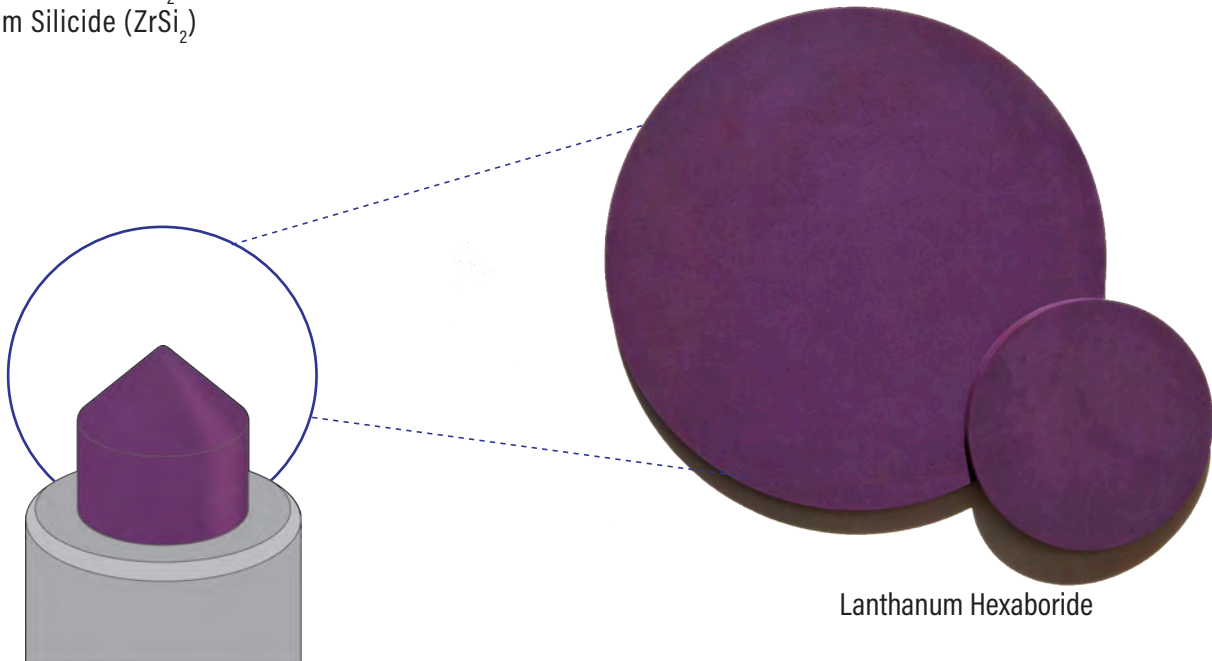
Molybdenum Silicide (MoSi₂)
Titanium Silicide (TiSi₂)
Tungsten Silicide (WSi₂)
Zirconium Silicide (ZrSi₂)

Borides

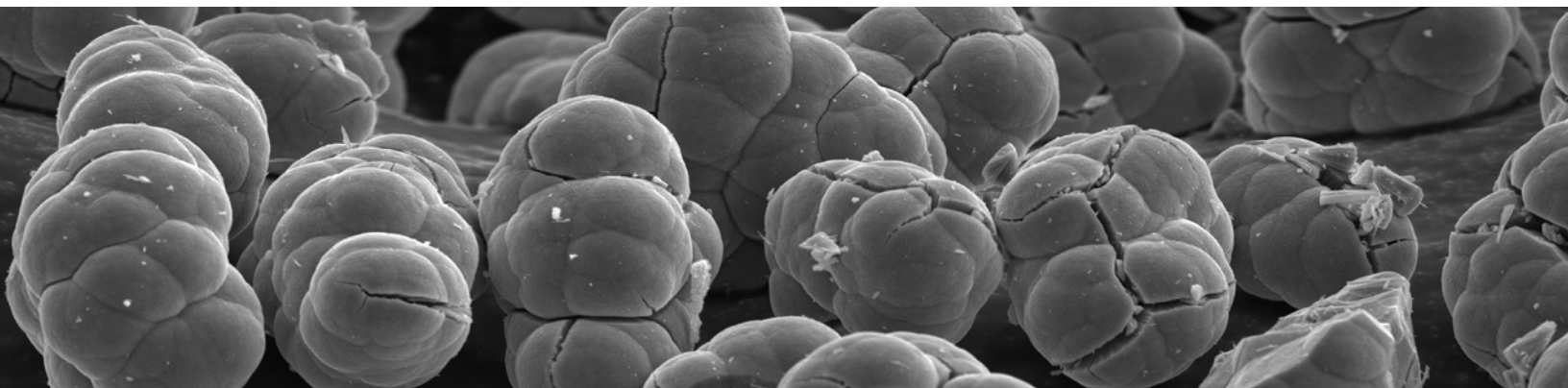
Calcium Boride (CaB₆)
Chromium Boride (CrB₂)
Cobalt Boride (Co₂B)
Gadolinium Boride (GdB₆)
Hafnium Boride (HfB₂)
Iron Boride (FeB)
Lanthanum Boride (LaB₆)
Magnesium Boride (MgB₂)
Molybdenum Boride (MoB)
Nickel Boride (NiB)
Niobium Boride (NbB₂)
Samarium Boride (SmB₆)
Silicon Boride (SiB₆)
Tantalum Boride (TaB)
Titanium Boride (TiB₂)
Tungsten Boride (W₂B)
Vanadium Boride (VB₂)
Zirconium Boride (ZrB₂)



Lanthanum Hexaboride rod



Lanthanum Hexaboride



Ultra-high purity Titanium Dioxide powder

Oxides

Bismuth Oxide (Bi_2O_3)
 Dysprosium Oxide (Dy_2O_3)
 Europium Oxide (Eu_2O_3)
 Gadolinium Oxide (Gd_2O_3)
 Germanium Oxide (GeO_2)
 Holmium Oxide (Ho_2O_3)
 Magnesium Oxide (MgO)
 Molybdenum Oxide (MoO_3)
 Niobium Oxide (Nb_2O_5)
 Scandium Oxide (Sc_2O_3)
 Silicon Oxide (SiO_2)
 Tantalum Oxide (Ta_2O_5)
 Tin Oxide (SnO_2)
 Titanium Oxide (TiO_2 , Ti_3O_5)
 Tungsten Suboxide (WO_x)
 Yttrium Oxide (Y_2O_3)
 Zinc Oxide (ZnO)

Transition Metal Oxides

Aluminum oxide (Al_2O_3)
 Chromium Oxide (Cr_2O_3)
 Cobalt Oxide (Co_3O_4)
 Copper Oxide (Cu_2O)
 Hafnium Oxide (HfO_2)
 Iron Oxide (FeO , Fe_2O_3 , Fe_3O_4)
 Manganese Oxide (MnO_2)
 Vanadium Suoxide (VO_x)
 Yttrium Aluminum Oxide ($\text{Y}_3\text{Al}_5\text{O}_{12}$)
 Zirconia (ZrO_2)



Pre-melted Tantalum Suboxide



Aluminum Oxide Crucible

THERMAL SPRAY COATING MATERIALS

Thermal spraying is an industrial coating process that consists of using a heat source (flame or otherwise) and a coating material in powder or wire form, which is melted into tiny droplets and sprayed onto surfaces at high velocity.

Thermal spray is commonly used to produce protective coatings to mitigate severe corrosion, high temperatures stress, chemical stress, environmental abrasion, and other hazards.

Advanced materials systems utilize thermal spray coatings to impart electrical insulation or conductivity properties, oxidation resistance, and a number of other performance improvements.

LTS Research Laboratories, Inc. offers engineered thermal spray metals, alloys, carbides, oxides, and composites. LTS custom produces alloys and compounds with tailored morphological, flowability, and performance properties to enhance thermal spray coating applications. Many of the following materials are available in spherical water/gas atomized or spray-dried forms.

Alloys

Aluminum Silicon (Al/Si)
Copper Gallium (Cu/Ga)
Nickel Aluminum (Ni/Al)
Nickel Chromium (Ni/Cr)
Nickel Chromium Iron (Ni/Cr/Fe)
Nickel Chromium Iron Cobalt (Ni/Cr/Fe/Co)
Nickel Vanadium (Ni/V)
Tantalum Aluminum Vanadium (Ta/Al/V)

Ceramics

Alumina Titania ($\text{Al}_2\text{O}_3\text{-TiO}_2$)
Aluminum Oxide (Al_2O_3)
Chromium Oxide (Cr_2O_3)
Titanium Oxide (TiO_2)
Yttrium Oxide (Y_2O_3)
Zirconia-Yttria ($\text{ZrO}_2\text{-Y}_2\text{O}_3$)

Carbides

Chromium Carbide (CrC_2)
Chromium Carbide Composite (with transition metal blend)
Titanium Carbide (TiC)
Tungsten Carbide (WC)
Tungsten Carbide Composite (with transition metal blend)

Metals

Aluminum (Al)
Cobalt (Co)
Copper (Cu)
Molybdenum (Mo)
Nickel (Ni)
Silver (Ag)
Titanium (Ti)
Zinc (Zn)

RARE EARTHS & THEIR ALLOYS

LTS offers Rare Earth Metals & Alloys at TREM 99.5%+
Gadolinium Containing Alloys

Samarium Containing Alloys

Holmium Containing Alloys

Terbium Containing Alloys

Lanthanum Containing Alloys

Thulium Containing Alloys

Lutetium Containing Alloys

Ytterbium Containing Alloys

Neodymium Containing Alloys

Europium Containing Alloys

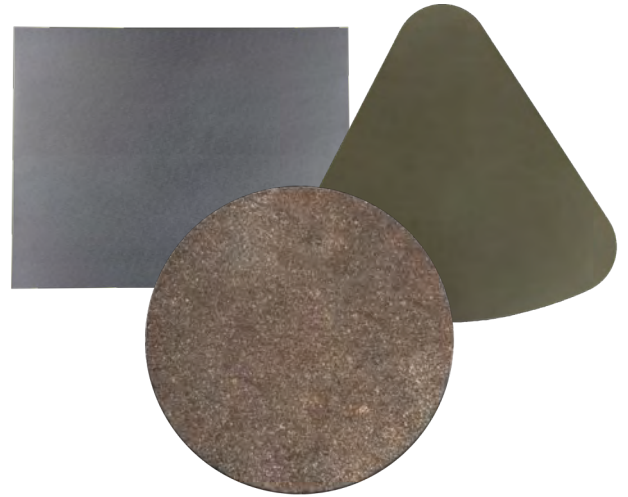
Cerium Containing Alloys

Praseodymium Containing Alloys

Dysprosium Containing Alloys

Sputtering Targets

DC/RF sputtering deposition is a popular process that uses targets typically shaped as large homogeneous discs. We produce targets from 1" to 18" diameter as well as planar and special style targets like delta and ConMag.



Powders

Synthesized and classified to particle sizes ranging from micron to a millimeter scales as per specification. Nanopowders are also available for select materials as well as thermal spray-grade powders (+325, -100 mesh).



Granules, Pellets & Needles

Pellets are offered for use in evaporation processes including E-beam and PLD.





Inserts

At LTS, we manufacture superior e-beam inserts for UHV deposition in metal, oxide, suboxide or fluoride formulations. Typically produced from ultra-high purity ingots, they are supplied in standard sizes from 10 to 100 cc. Customized shapes and sizes are available.



GEOMETRIES



Ingots

Ingots are offered in almost every composition that we produce. E-beam melting, vacuum induction melting, and tube furnace melting under gas flow is employed. Ingots are available in the highest purities, and are not subjected to impurities from additional processing like in grinding or mechanical powder formation.



Foils, Sheets & Wires

E-beam melted, VIM melted, and hot pressed malleable metals and alloys, including high purity Rare-Earths, are available in thicknesses down to 0.1 mm for foils/sheets and 0.1 mm diameters for wires.

BACKING PLATES & BONDING

LTS manufactures custom backing plates to suit your specific sputtering process. The selection of the appropriate backing plate is critical for high quality sputtering processes as it is used to properly mount an often fragile target within the sputtering system.

We offer backing plate materials such as oxygen-free high conductivity copper (OFHC), molybdenum, copper, copper-chromium, stainless steels, and other alloys.

We employ Indium and proprietary silver-epoxy bonding agents chosen to provide high electrical and thermal conductivity, prevent target-backing plate interface diffusion, and alleviate stress caused by differing thermal expansion coefficients.

Our low-temperature silver-epoxy mitigates thermal shock for ceramic and glass targets, and is strong enough to support top-mounted 18" dia. chalcogenide glass targets.

Different bonding techniques are employed by LTS, depending on the materials being used. Some of the most common techniques used are:

1. Cold Bonding
2. Diffusion Bonding
3. Explosion Bonding
4. Plasma Activated Sintering



STARTER SOURCES

LTS manufactures superior quality E-beam deposition cones and starter sources for the thin film industry. A range of sizes are offered in metal, oxide, suboxide, and fluoride forms. Although standard sizes are 13 cc, 15 cc, 20 cc, 25 cc, and 40 cc, we offer custom sizing and crucible design. Pre-melted suboxides of the following materials are also available.



Metal

Aluminum (Al)
Chromium (Cr)
Gold (Au)
Magnesium (Mg)
Nickel (Ni)
Niobium (Nb)
Palladium (Pd)
Platinum (Pt)
Scandium (Sc)
Tantalum (Ta)
Titanium (Ti)
Vanadium (V)

Oxides

Aluminum Oxide (Al_2O_3)
Hafnium Oxide (HfO_2)
Indium Oxide (In_2O_3)
Molybdenum Oxide (MoO_3)
Scandium Oxide (Sc_2O_3)
Silicon Oxide (SiO_2)
Tantalum Oxide (Ta_2O_5)
Titanium Oxide (TiO_2)
Tungsten Suboxide (WO_x)
Zirconium Oxide (ZrO_2)

Fluorides

Gadolinium Fluoride (GdF_3)
Magnesium Fluoride (MgF_2)
Ytterbium Fluoride (YbF_3)

Alloys

Cobalt Chromium (Co/Cr)
Gold Germanium (Au/Ge)
Gold Nickel (Au/Ni)
Nickel Palladium (Ni/Pd)
Nickel Vanadium (Ni/V)

CUSTOM & SPECIALITY MANUFACTURING

LTS Research Laboratories, Inc. utilizes the following array of manufacturing methods:

General

Hot Pressing (HP): A powder compaction method in which the external pressure and temperature are applied to the material to increase its density. The powder is placed in the die between movable metal rams, uniaxial pressure is applied, and the entire system is held at elevated temperatures.

Diameter available: 1" – 18"

Cold Pressing (CP): Similar to HP, powder is pressed into bulk form at high pressures and room temperature.

Hot Isostatic Pressing (HIP): A powder compaction method capable of ultra-high density compacts (>99% rel. density) achieved by the application of isostatic pressure at elevated temperatures.

Ceramics

Solid State Diffusion Sintering: Powder components are mixed together and held at high temperature, forming a compound without melting.

Slip Casting: Used to shape ceramic parts, this process involves preparing the liquid clay slip, casting the slip in a plaster mold, removing the mold, air drying the cast piece, glazing the dried product, then sintering the green form in a furnace.

Metals

Vacuum Induction Melting (VIM): Metals are melted by electromagnetic induction under vacuum.

VIM-HP: Components are initially alloyed with VIM, e-beam melting, or diffusion sintering. The bulk mixture is then pulverized into powder and hot pressed back into shape to remove natural anisotropies and maintain compositional homogeneity.

Vacuum Arc Melting (VAM): Consumable metal electrodes are subjected to high current under vacuum to melt and produce homogeneous refractory alloys.

E-Beam Melting: An e-beam is concentrated to melt materials at extremely high temperatures. Typically employed for ultra-high melting temperature and refractory materials, e-beam melting is also used purify products by concentrating impurities in a locally induced melt and separating the low purity concentrate from the bulk.

Cold Crucible Induction Levitation Melting: Magnetic metals are suspended in a high strength electric field and simultaneously melted. The high-purity melt never contacts a crucible and is not exposed to any additional impurities.

Speciality

Microreactors: Used for military grade (MIL-SPEC compliant) fluoride production.

High Precision Machining: Waterjet, lathes, mills, surface grinding, and unique precision-machined part production, including complex components such as dental and bone implants.

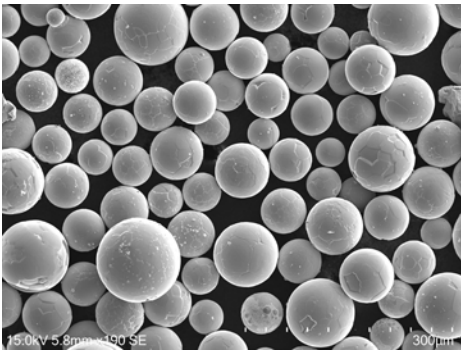
OUR R&D PHILOSOPHY

Our R&D philosophy is based on the principle of delivering product with strict adherence to customer specification, backed by comprehensive manufacturing capabilities and advanced materials characterization, to make our customers' work seamless, easy, and cost effective.

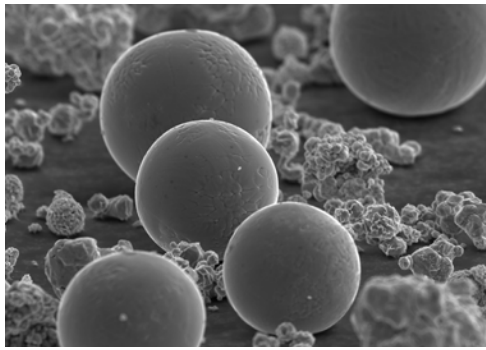
We start by having comprehensive discussion with our customers to understand their material requirements, performance criteria, and assess our manufacturing capability. We then begin the R&D process with the following steps:

- Synthesis (chemical composition, level of dopants, powder homogenization, gas flow, etc),
- Processing (annealing conditions, texturing, grinding or machining),
- Detailed characterization (please refer to Analytical Services)
- Soliciting feedback on the deposited material properties, then
- Refining our synthesis and processing protocols.

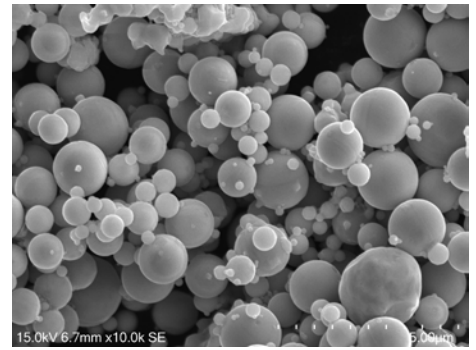
Several R&D cycles are in order to deliver on new formulation.



Chromium Powder



Ti-Al-V Powder



Nickel Powder

Milestone Achievements:

1992: LTS acquires a manufacturing plant from the Academy of Sciences named New Material and Technology and begins research and development of new materials for the opto-electronics materials industry. The newly developed DFM process allows for large-scale production of MIL-Spec. compliant fluorides. LTS increases specialization in the production of performance chemicals, solvents, and resins.

1997: LTS formalizes its Advanced Analytical Technologies (AAT) branch to improve its analysis capabilities.

1997: LTS opens another research and development division with the participation of Dr. Q. Ahsan, Dr. W. Xing, Dr. X. Chu, Dr. E. Galkevych, and Dr. A. Ignatov.

1998: LTS begins full scale development and use of the LFP process for the production of ultra high purity hafnium oxide (HfO_2) with very low zirconium oxide (ZrO_2), tantalum oxide (Ta_2O_5), and low iron (Fe).

2003: Installation of LTS's first 8 inch diameter hot press machine.

2005: Large sized target production capabilities advances with the installation of a 14 inch diameter hot press and vacuum induction furnace with 500 liter, 1800 °C, and 250 ton capacity.

2008: LTS installs a dual chamber vacuum hot press to manufacture up to 495 mm diameter sputtering targets.

2010: LTS brings its 18½ inch diameter multistack hot press online, with production capabilities of up to 900 tons of pressure and max operating temperature 2100 °C.

2012: LTS introduces new chalcogenide glasses and perovskites to the thin film and semiconductor industries - PZT, PLZT and PMN-PT.

2017: LTS introduces and excels in the production of trending battery chemicals, high purity iodides and specialty sub-oxides.

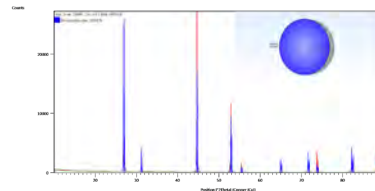
2019: LTS offers commercial analytical services including XRD, SEM, ICP-MS and PSD.

ANALYTICAL SERVICES

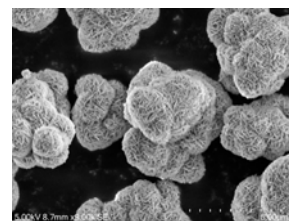
Analytical Technique	Applications	LTS Equipmemnt
X-ray Diffraction (XRD)	<ul style="list-style-type: none"> • Crystal Structure determination • Phase identification • Quantitative and qualitative analysis • Residual strain • Texture analysis • Crystallinity 	Malvern Panalytical X'Pert ³ Powder (X'Pert PRO MPD) X-ray diffractometer and High Score Plus analysis software
Scanning Electron Microscope (SEM)	<ul style="list-style-type: none"> • Topographical information • Surface and Sub-surface analysis • Particle shape determination • Particle size distribution • Failure analysis 	Hitachi SU3500 SEM with EDAX Octane Elect EDS system
Energy Dispersive Spectroscopy (EDS)	<ul style="list-style-type: none"> • Compositional and Elemental analysis of the samples • Quantitative analysis of the samples. 	
Optical Microscope	<ul style="list-style-type: none"> • To magnify samples at fairly low magnification, around 1000x. • Liquid samples 	Olympus BH2
Particle Size Distribution (PSD)	<ul style="list-style-type: none"> • Range of particle size • Average particle size of any powder sample. 	Microtrac S3000
Ball Mill	<ul style="list-style-type: none"> • To grind down powder samples to required size 	DECO PBM-2L Retsch PM400
Gas Chromatography Mass Spectroscopy (GC-MS)	<ul style="list-style-type: none"> • Determination of trace elements • Identification of unknown samples • Environmental Analysis 	Hewlett Packard 5973 Mass selective detector which is a transmission quadrupole mass spectrometer



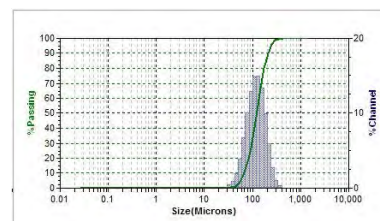
X-Ray Diffractometer



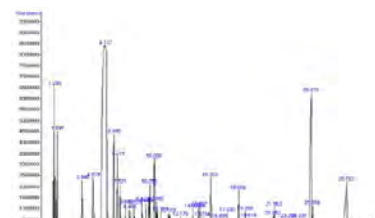
Scanning Electron Microscope



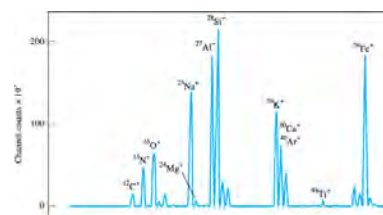
Laser Diffraction Particle
Size Distribution



Gas Chromatograph Mass
Spectrometer



Graphite Furnace Atomic Absorption
Spectrometer





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