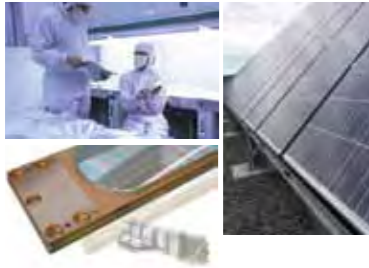


Sputtering Targets,

Pellets & Wire (Vapor Deposition)
(For Flat Panel Display, Photovoltaic,
Semiconductor, and Other Applications)



Enhanced global system support ranging from R&D of new materials to production and supply

ULVAC, Inc. delivers total solutions for manufacturing equipment needed to produce solar cells, FPD, integrated circuit devices and countless other products. As part of these solutions, the ULVAC global production system delivers high quality, stable and low cost supply of sputtering targets and various vapor deposition materials by making maximum use of its best features as an equipment manufacturer. ULVAC facilities also include the Institute for Super Materials which is a professional R&D facility for new materials. ULVAC also works closely with nearby production plants to support a broad range of needs ranging from trial production of samples for next-generation materials, to material supply, and technical consultations on mass production line operation.

ULVAC TOHOKU Inc.
(contractor company)

ULVAC, Inc.
Materials Division – PM Department
(Chiba Tomisato Plant)

ULVAC Materials Korea, Ltd.
(contractor company)

ULVAC Materials (Suzhou) Co., Ltd.
(contractor company)

ULVAC KYUSHU CORPORATION
(contractor company)

ULVAC MATERIALS TAIWAN, Inc.

ULVAC MALAYSIA SDN BHD.

ULVAC Materials Korea, Ltd.
2-1, 2-2B/L, Dangdong-Jigu, Munsan high tech industrial complex,
Dangdong-Ri, Munsan-Eup, Paju-Si, Kyonggi-Do, Korea 413-902
TEL:(+82)31-937-2900

ULVAC Materials (Suzhou) Co., Ltd.
No.55, Pingsheng Road, Industrial Park, Suzhou, China
TEL:(+86)512-8777-0123

ULVAC MATERIALS TAIWAN, Inc.
No.37, Keya Rd., Daya Distric, Taichung City 42878, Taiwan (R.O.C)
TEL:(+886)4-2565-8299

ULVAC MALAYSIA SDN. BHD.
No.8, Jalan Gitar 33/3, Elite Industrial Estate Off Jalan, Bukit, Kemuning
40350, Shah Alam, Selangor, Malaysia
TEL:(+60)3-5121-4700

Chiba Tomisato Plant (left) and
Chiba Institute for Super Materials (right)

ULVAC Materials Korea, Ltd. (Korea)

ULVAC Materials (Suzhou) Co., Ltd. (China)

ULVAC MALAYSIA SDN. BHD. (Malaysia)

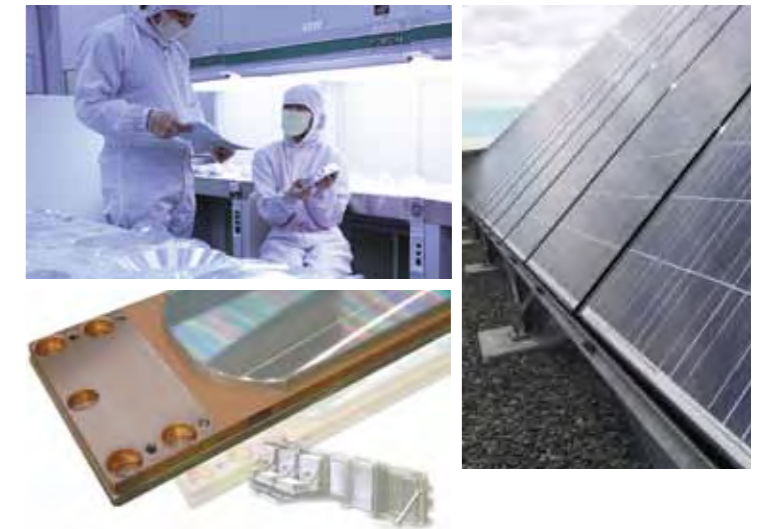
ULVAC

ULVAC, Inc.

Sputtering Targets,

Pellets & Wire (Vapor Deposition)

(For Flat Panel Display, Photovoltaic,
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ULVAC ULVAC, Inc., Materials Division

●Contact
ULVAC, Inc. URL: <http://www.ulvac.co.jp/eng>
Materials Division – PM Department
Chiba Tomisato Plant: 10-1 Misawa, Tomisato, Chiba 286-0225, Japan TEL: +81-476-90-6111

Manufacturing contractor company
ULVAC TOHOKU Inc. URL: <http://www.ulvac-tohoku.com>
6-1-16 North Inter-Industrial Park, Hachinohe, Aomori 039-2281, Japan TEL: +81-178-20-2200
ULVAC KYUSHU Corp. URL: <http://www.ulvac-kyushu.com>
3313-1 Yokogawa-cho Ue, Kirishima, Kagoshima 899-6301, Japan TEL: +81-995-72-1114

● This catalog is subject to change without notice to reflect performance improvements, etc.

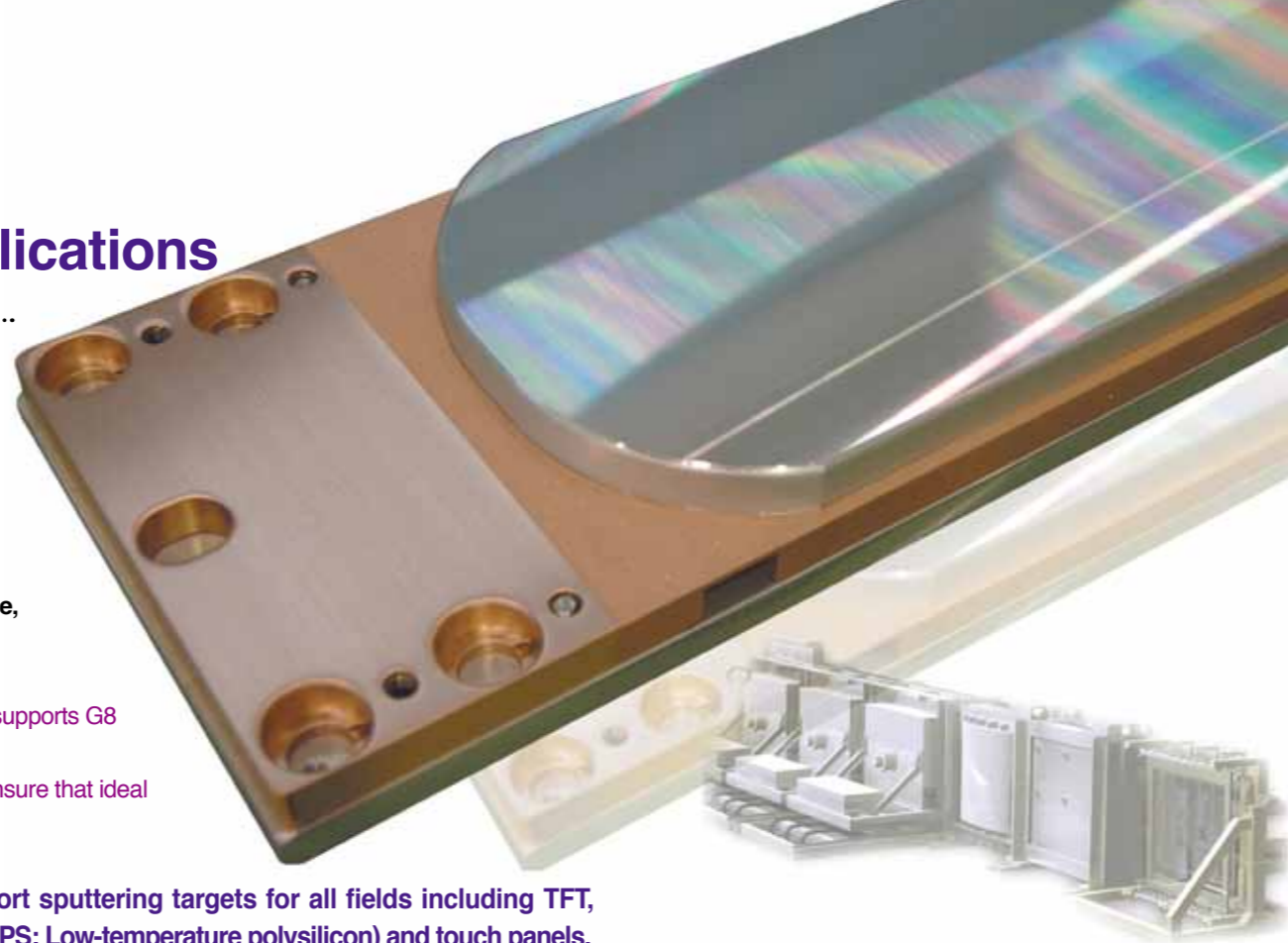
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Sputtering Targets for Flat Panel Display Applications

Large Sizes & Diverse Display Types In the FPD (Flat Panel Display) Market, We Constantly Work to Maintain a Stable, High-Quality Material Supply

WE DO THE FOLLOWING to ensure our customers have stable, high quality materials needed for flat-panel displays

- We obtain materials from sources all over the world
- Our quality control facilities and system support large targets (supports G8 generation and even super-large glass substrates)
- We work along with the Chiba Institute of Super Materials to ensure that ideal materials are provided to customer production processes



▲ Enhanced Inspection System Contributing to Quality Improvement

- We support sputtering targets for all fields including TFT, OLED (LTFS: Low-temperature polysilicon) and touch panels.
- Ultrasonic defect testers ensure meticulous quality assurance!

FPD manufacturing equipment sizes are becoming larger and larger so sputtering target dimensions are also increasing. To improve both production equipment and QA equipment, ULVAC has installed large ultrasonic test equipment to make meticulous defect inspections of materials and bonding inspections. Using this equipment has helped ULVAC drastically cut down on arcing during sputtering and deliver high quality targets.

High-reliability metal bonding technology

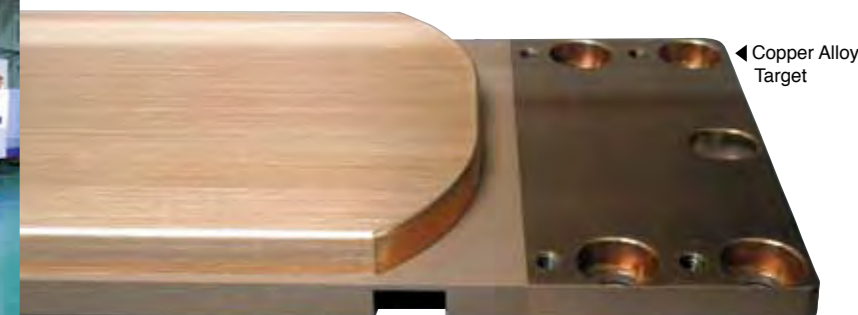
Large sputtering targets are very heavy so technology for bonding to a cooling plate (backing plate) is extremely important. ULVAC has installed bonding equipment to support deposition of larger glass substrate, and realized an all-inclusive target supply system.

▼ Processing Machine for Large Sizes



Targets for manufacturing equipment of FPDs

Application Field	Materials	Manufacturing Method	Purpose of Use
Low temperature poly-Si TFT materials	Al (5N) & Al alloy	Melting method	Wiring materials
Mobile terminals/monitors	Ti (4N5)	Melting method	Electrode/barrier materials
	Mo (3N)	Powder sintering	Electrode/barrier materials
	ITO (4N)	Powder sintering	Transparent conductive films
High temperature poly-Si TFT materials	AlSi (5N) & AlCu (5N)	Melting method	Wiring materials
Rear projection televisions	Ti (4N5)	Melting method	Electrode/barrier materials
High-definition monitors	WSi	Powder sintering	Electrode materials
	ITO (4N)	Powder sintering	Transparent conductive films
PDP	Al (5N) & Al alloy	Melting method	Wiring materials
PDP-TV	Cr (3N)	Powder sintering	Barrier/ adhesion film materials
	Cu (4N)	Melting method	Wiring materials
	ITO (4N)	Powder sintering	Transparent conductive films
OLED (organic EL) materials	ITO (4N)	Powder sintering	Transparent conductive films
Mobile terminals	Ag & Ag alloy	Melting method	Reflective/ electrode
	Mg	Melting method	Electrode
	Al & Al alloy	Melting method	Wiring/electrode
FED/SED materials	Al (5N) & Al alloy	Melting method	Wiring materials
Monitors/TVs	Cr (3N)	Powder sintering	Barrier/ adhesion film materials
	Various precious metals (4N)	Melting method	Wiring materials
	ITO (4N)	Powder sintering	Transparent conductive films
	Nb (3N)	Melting method	Electrode materials
STN, color filter materials	Si & SiO ₂ (4N)	Melting method	Insulating/ under-layer material
Mobile phones/ terminals	Cr (3N)	Powder sintering	BM materials
	Ag alloy (4N)	Melting method	STN reflective electrode materials
	ITO (4N)	Powder sintering	Transparent conductive films
Amorphous Si-TFT materials	Al (5N) & AlCe alloy	Melting method	Wiring materials
	Cu (4N) & Cu alloy	Melting method	Wiring materials
	Mo (3N)	Powder sintering	Electrode/barrier materials
	Cr (3N)	Powder sintering	Electrode/barrier materials
	Ti (3N)	Melting method	Electrode/barrier materials
	ITO (4N)	Powder sintering	Transparent conductive films



◀ Copper Alloy Target

ULVAC's High Quality Targets Contribute to High-Functional Films for FPDs.

ITO Targets

Four Major Features of ULVAC Targets

- Stable and enhanced discharge during deposition through refinement and high dispersion of SnO₂
- Good roughness of target surface
- High stability of film resistance after deposition
- Low particle

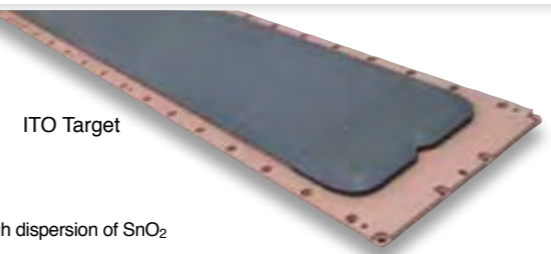
Other Targets

Si Targets

Nb Targets

Product Line of ITO Targets

Item	Analysis method	Allowable level	Unit/composition	In ₂ O ₃ -10wt%SnO ₂	In ₂ O ₃ -5wt%SnO ₂	In ₂ O ₃ -3wt%SnO ₂
Resistivity	Four probe method	-	mΩ·cm	0.14 - 0.17	0.12 - 0.14	0.12 - 0.14
Composition/ impurity element	SnO ₂	XFS	%	10.1 - 9.9	5.0	3.0
	Fe	ICP-AES	ppm	5.8 - 2.2	5.6	5.9
	Cu	ICP-AES	ppm	2.4 - < 1	1.8	1.0
	Pb	ICP-AES	ppm	< 4	< 4	< 4
	Al	ICP-AES	ppm	3.8 - < 1	1.5	1.0
	Ni	ICP-AES	ppm	1.0 - < 1	< 1	1.1

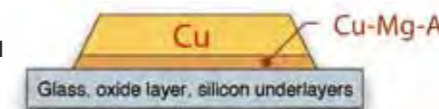


ITO Target

Cu-Mg-Al Alloy for Low-Resistance Copper Wiring

Good lower adhesion layer in low-resistance Cu wiring process

- Ideal target for deposition forming in low-resistance wiring processes. (Stacking structure uses Cu-Mg-Al alloy as adhesion layer for pure copper film)
- Good adhesion to glass substrates, oxide layers (ITO, etc.), and silicon system under layers (SiO₂).
- Wet etch processing is easy because the copper material is similar to the wiring layer material. (Processing can also use etching solution (single fluid) not containing hydrogen peroxide or fluoric acid.)
- Low-cost process
- Inexpensive target material



Wiring resistance of various metal materials

Cu	2.2μΩcm
Mo	12-15μΩcm
a-Ta	25μΩcm
Cr	20μΩcm
Al Alloy	4-5μΩcm
Al	3-3.5μΩcm
Ag	3.0μΩcm

(Film thickness: 300nm)

*Silver (Ag) has low bulk resistance but its resistivity as a thin film is the same as aluminum (Al).

Sputtering Targets for Photovoltaic Applications

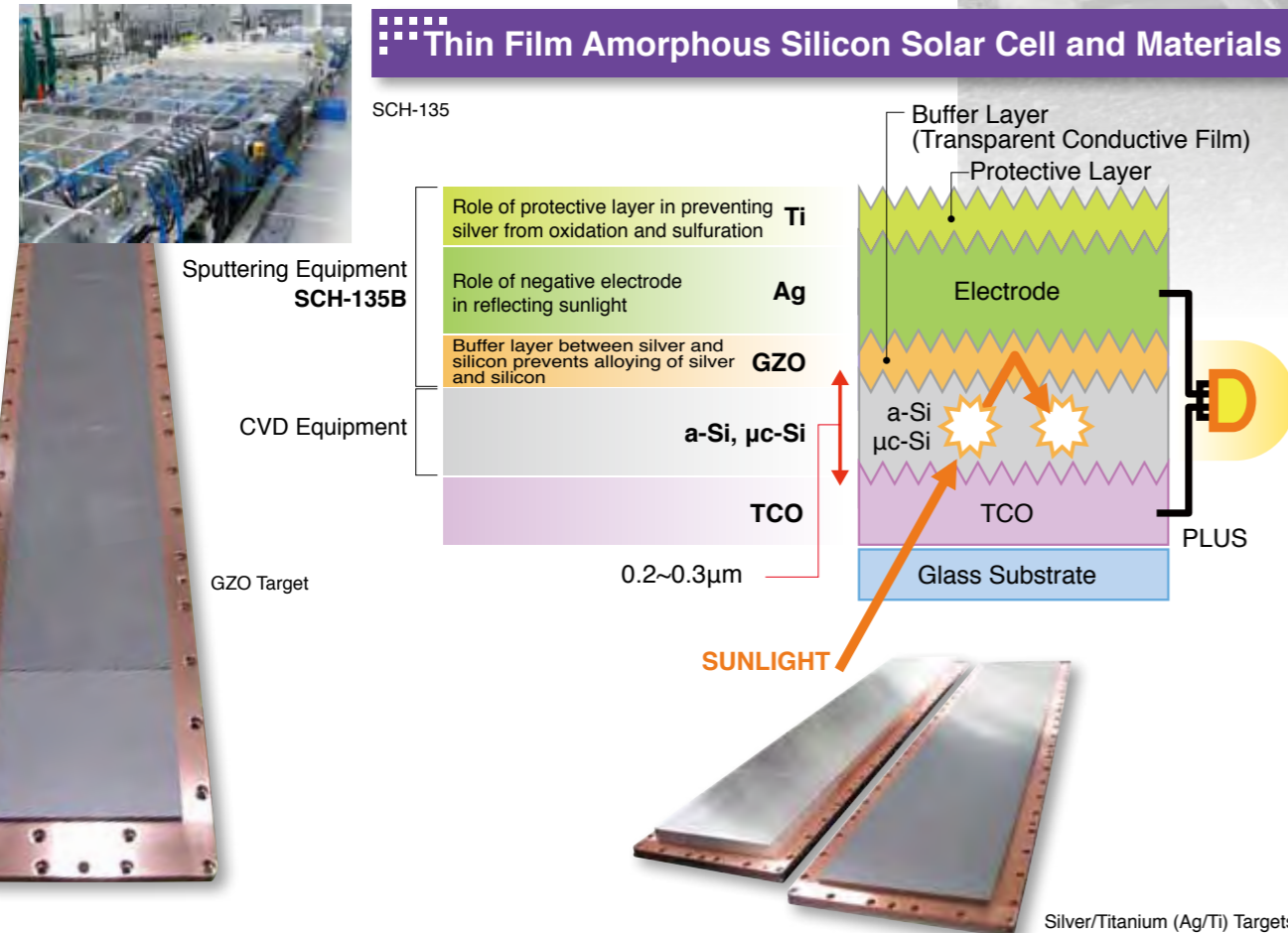
Sputtering Targets for Total Material Support of Thin Film Solar Cell Manufacturing Equipment

Besides promoting widespread use of its turn-key or "ready-to-go" thin-film solar cell manufacturing equipment, ULVAC also provides sputtering targets made from materials ideal for passivation, buffer and electrode layers in amorphous silicon solar cells and compound semiconductor (CIGS) solar cells. ULVAC responds to needs for transparent, electrically conductive films widely used not only in solar cells but also in FPD and touch panels. It provides for example, GZO and AZO thin films using zinc that is a plentiful resource compared to ITO by utilizing an all-inclusive integrated system ranging R&D, to production engineering, and global supply.



Solar Cell Integrated Production Line

Thin Film Amorphous Silicon Solar Cell and Materials

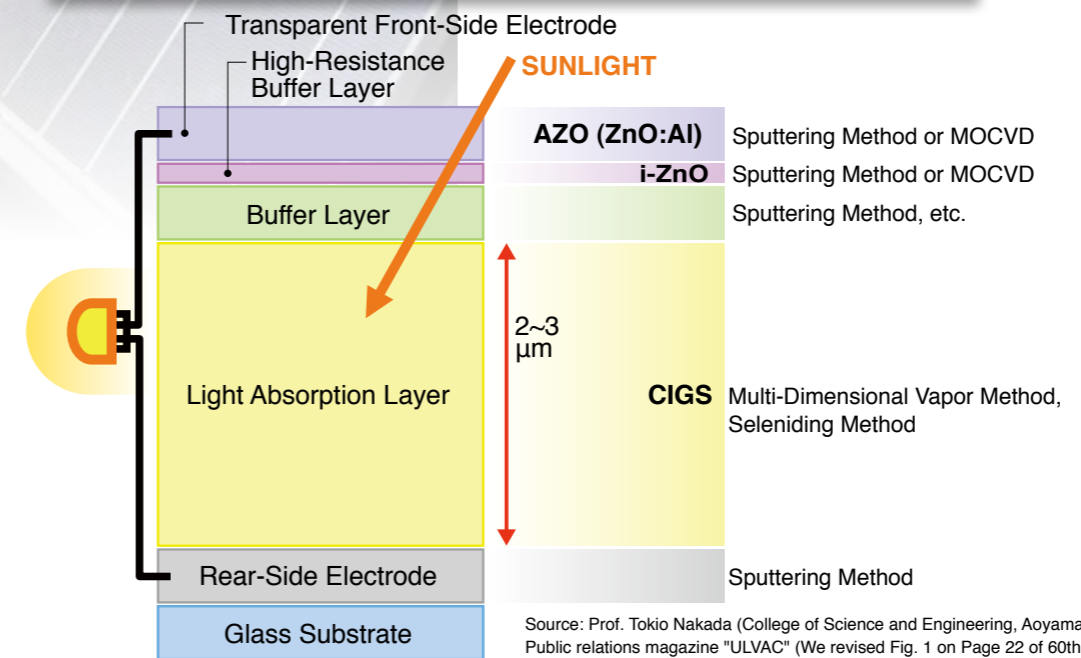


Targets for Solar Cells

Materials	AZO	GZO	Ag	Ti	Al alloy	ITO
Purity	3N -	3N -	4N	3N -	5N	4N
Manufacturing Method	Powder sintering	Powder sintering	Melting method	Melting method	Melting method	Powder sintering
Main Application	Transparent conductive films	Transparent conductive films	Reflective film electrode materials	Electrode material protection films	Wiring materials	Transparent conductive films

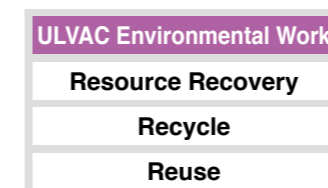
Materials	Cu	In	CuGa	Si	SiO ₂	Mo	ZnO
Purity	4N	4N	- 35wt%Ga	5N -	4N	3N	3N
Manufacturing Method	Melting method	Melting method	Powder sintering	Melting method	Melting method	Powder sintering	Powder sintering
Main Application	Precursors	Precursors	Precursors	Passivation films	Protection films	Electrode materials	Transparent conductive films

Thin Film Compound (CIGS) Solar Cell and Materials

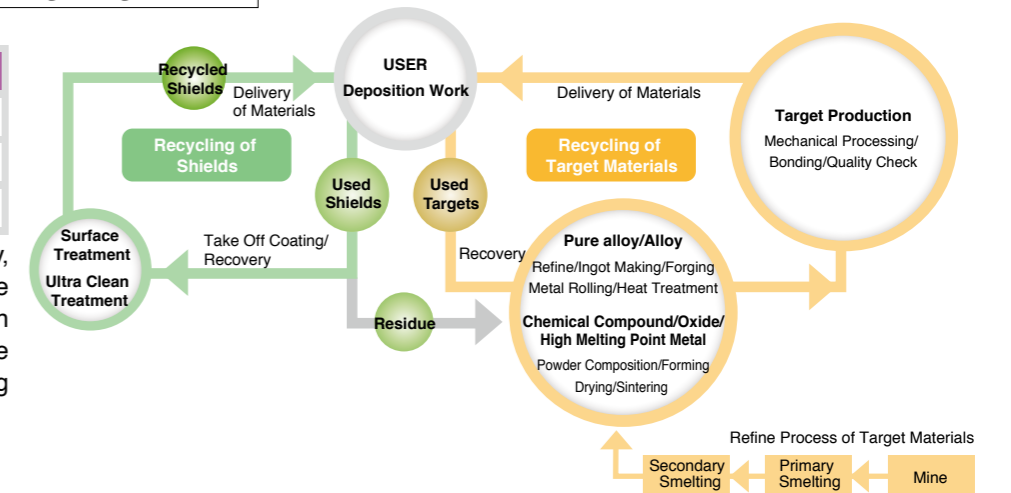


Source: Prof. Tokio Nakada (College of Science and Engineering, Aoyama Gakuin University) Public relations magazine "ULVAC" (We revised Fig. 1 on Page 22 of 60th edition.)

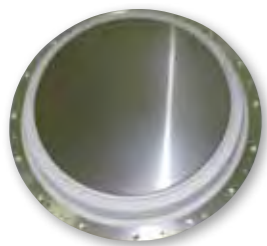
Recycling of Sputtering Targets



At ULVAC, resource recovery, recycling and reuse of valuable rare metals are implemented in a proactive manner to pursue efficient use of sputtering targets.



Sputtering Targets for Semiconductor Applications



ULVAC Semiconductor Target Materials

—Always a Leader in Materials on the Cutting Edge of New Technology

Sputtering targets must meet ever tougher standards for high quality to produce sub-micron scale and wafer targets in ever larger sizes

- Low particle
- Good film uniformity
- High usage efficiency

— To develop and produce high quality sputtering targets, Ulvac carefully evaluates which manufacturing method to use for each material to meet the following product quality goals.



■ Sputtering targets made using optimum manufacturing methods!

ULVAC has developed 2 types of tungsten targets for different manufacturing methods depending on the particular application required by the semiconductor process. One type was developed for products at a purity grade of 5N is an inexpensive and employs the powder sintering method. High-purity CVD tungsten target boasting a purity grade of 7N and using CVD (chemical vapor deposition) on sections requiring higher quality.

ULVAC in this way provides the customer with high performance by using the ideal target manufacturing method to meets specifications needed for a particular semiconductor process.

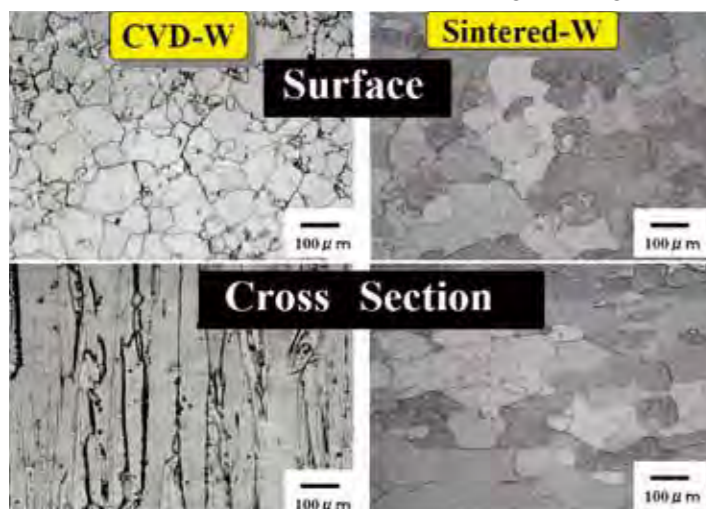
■ Low-particle targets

ULVAC has developed sputtering targets that suppress generation of particles that can be the source of problems in the sputtering process. Gaseous elements are one factor in causing particle emissions especially in aluminum targets and we are working to lower emissions by utilizing a vacuum melting method in the refining and ingot purification processes.



Glow Discharge Mass Spectrometer

■ Comparison of Metal Microstructures in Tungsten Targets



■ GDMS Analysis/Comparison for Various Tungsten Targets

Target	Sinter-W	CVD-W
Na	≤ 0.1	≤ 0.01
K	≤ 0.1	≤ 0.01
Mg	—	≤ 0.01
Ca	—	≤ 0.01
Al	≤ 1	≤ 0.03
Cr	≤ 1	≤ 0.03
Fe	≤ 1	≤ 0.03
Ni	≤ 1	≤ 0.03
Cu	≤ 1	≤ 0.01
Th	≤ 0.0005	< 0.0002
U	≤ 0.0005	< 0.0002
O	≤ 100	≤ 30
C	≤ 50	≤ 30

(ppm)



■ Targets for Semiconductors

Application Field	Materials	Manufacturing Method	Purpose of Use
Electrode materials	W (5N)	Powder sintering	
	W (6N, 7N)	CVD	
	Co (5N)	Melting method	
	Ni (5N)	Melting method	
	Ti (5N)	Melting method	
	Various silicide (4N up)	Powder sintering	
Wiring Materials	Al (5N, 5N5) & Al alloy such as AlCu (5N, 5N5)	Vacuum melting method	
	Cu (6N)	Melting method	
Compound semiconductor materials	Au, Au alloy (4N)	Melting method	Wiring
	WSi (5N)	Powder sintering	Electrode
	SiO ₂ (4N, 6N)	Artificial/ natural quartz	Insulating material
Mounting & wiring	Al (5N, 5N5) & Al alloy (5N, 5N5)	Vacuum melting method	Wiring
	Cu (4N)	Melting method	Wiring
	Cr (3N)	Powder sintering	Barriers
	Precious metal materials	Melting method	Wiring
	TiW (4N up)	Powder sintering	Barriers
	Ni (4N)	Melting method	Barriers
Capacitor materials	BST	Powder sintering	DRAM/thin film capacitors
	PZT	Powder sintering	FeRAM
Barrier materials	Ti (4N5)	Melting method	
	TiW (4N up)	Powder sintering	

■ Attaining high uniformity by adjusting the metal microstructure

ULVAC uses manufacturing processes that ensure high uniformity and a fine metal microstructure in most of its targets for semiconductor products including high purity cobalt targets and titanium targets.

Utilizing a fine metal microstructure having a high degree of uniformity for example allows increasing the magnetic flux leakage on the target surface of high purity cobalt targets (low permeability) so expanding the erosion area provides a more uniform film thickness along with higher area usage efficiency.

■ Meticulous quality control system

Integrated process manufacturing at ULVAC takes product characteristics and contours into account during production. Sophisticated analysis/evaluation system such as the GD-MS (glow discharge mass spectrometer) ensure purity along with a high level of quality.

■ Target Material for Mainstream 300mm Wafers

Target Material	Al-0.5mass%Cu	Ti	Cu	Ta	W
Purity	5N5up (low-U, Th specifications)	4N5up	6Nup	6Nup (except for Nb and W)	5N, 6N, 7N
Manufacturing Method	Induction Melting Method (Vacuum)	Arc Melting/ EB Melting Method	Melting Method (Atmosphere)	EB Melting	Sinter, CVD
Backing plate Material	Aluminum or Copper Alloy	Aluminum Alloy	Aluminum Alloy	Aluminum or Copper Alloy	Aluminum or Copper Alloy
Bonding Method	Electron Beam Welding, Integrated Part Structure, or Metal Bonding	Diffusion Bonding	Diffusion Bonding	Diffusion Bonding	Metal Bonding

■ Evaporation Deposition Materials

Materials	Purity	Type	Size	Quantity
Al	5N	SAW-15	diameter 1.5xL	250gr
		SAP-06	diameter 6x15	200P
		SAP-22	diameter 22x14.6	20P
		SAS-40	diameter 49xdiameter 36x26H	3P
		SAS-110	diameter 69xdiameter 57x36H	2P
		5N5	MAP-06	diameter 6x20
Cr	5N8	CAP-06	diameter 6x20	10P
	6N		diameter 6x20	
	3N	SCS-1	4x30x1.5	100P
		SCS-2	6x8x4	100P
		SCP-4	20x20x6	5P
		SCH-10	diameter 32xdiameter 24x15	5P
	SCH-40-20	diameter 45xdiameter 35x20	2P	

Materials	Purity	Type	Size	Quantity
Cu	4N	ZMC-06	diameter 6x15	200P
	4N		10x3x7	100P
Ni	4N		10x14x7	10P
	4N		diameter 45xdiameter 35x20	2P
	4N		diameter 10x3	100P
Ti	3N		diameter 13x7.5	100P
	4N5		diameter 12x3.5	100P
	4N5		diameter 45xdiameter 35x20	2P
Ag Alloy	4N		diameter 10x15	50P
Mo	4N		diameter 10x5	10P

Our high-purity vacuum deposition materials are being used in all fields involving thin film electronic devices. Vapor deposition materials manufactured in a clean environment and under a sophisticated quality assurance system provide our customers with complete satisfaction.

*Besides our standard products, please feel free to consult us for special needs involving custom materials or contours, etc.

*We also handle all types of vacuum evaporation source components. Please tell us what you need and we will make every effort to fill your order.



High-Purity Vapor Deposition Materials