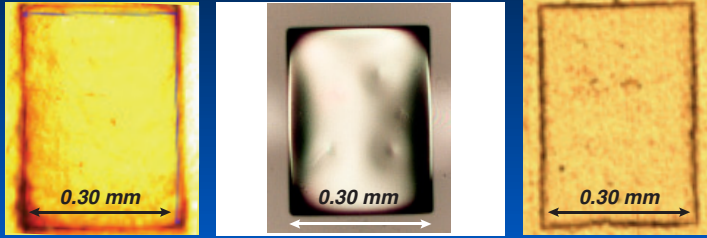


# COATING EXPERTISE

CVD, PVD, and Atomic Layer Deposition



Al / U:Cr comix / Al<sub>2</sub>O<sub>3</sub>

CH / Ta:Ti comix / CH

Be / CH / Be

Micrometer/submicrometer deposition & characterization

Multiple metrology techniques increase confidence in measured thickness, reduces uncertainty for simulations

- Quartz crystal / stylus profilometry / dual confocal microscope
- XRF and EDS provide elemental composition
- Auger spectroscopy for depth profile composition
- Contact radiography for areal density uniformity

Fabricated Opacity Targets					
Substrate	Coating	Tamper	Thickness (μm)		
CH	Fe	CH	12	0.25	0
Al	U	Al <sub>2</sub> O <sub>3</sub>	2	0.2	2
Al	Cr	Al <sub>2</sub> O <sub>3</sub>	2	1	2
Al	U:Cr comix	Al <sub>2</sub> O <sub>3</sub>	2	0.1:0.7	2
C	B:Ge comix	CH	3	2.0:0.5	1
Be	CH	Be	1	2	1
Be	CH	Be	1	4	1
Be	CH	Be	5	4	5
Be	CH	Be	5	2	5
Be	1 at% Ge-CH	Be	1	2	1
CH	Ti	Al	12	0.25	1
CH	Ti	Al	12	0.25	0
CH	Ti	CH	12	0.25	0
Al	Ti	Al	12	0.25	0
Al	Ti	Al <sub>2</sub> O <sub>3</sub>	1	0.5	1
Al	Ti	Al <sub>2</sub> O <sub>3</sub>	2	0.5	1
Al	Ti	Al <sub>2</sub> O <sub>3</sub>	2	1	1
CH	Ti	Al <sub>2</sub> O <sub>3</sub>	2	0.5	2
CH	Ti	Al <sub>2</sub> O <sub>3</sub>	1	0.25	1
CH	Gd:Ti comix	CH	12	0.25	0
CH	NaCl:Ti comix	CH	12	0.25	0
Al	Ta:Ti comix	Al <sub>2</sub> O <sub>3</sub>	2	0.1:0.5	1
CH	Ta:Ti comix	Al <sub>2</sub> O <sub>3</sub>	1	0.05:0.25	1
CH	Ta:Ti comix	Al <sub>2</sub> O <sub>3</sub>	1	0.03:0.15	1
C	Si	CH	3	1.5	1
C	Si	CH	3	5	1
C	Si	CH	3	2.4	3
C	Si	CH	3	1.5	1
C	Si	CH	3	3	1

Demonstrated Deposition																		He			
1																	2				
H																	He				
1.000																	4.003				
3	4															5	6	7	8	9	10
Li	Be															B	C	N	O	F	Ne
6.941	9.012															10.81	12.01	14.01	16.00	19.00	20.18
11	12															13	14	15	16	17	18
Na	Mg															Al	Si	P	S	Cl	Ar
22.99	24.31															26.98	28.09	30.97	32.07	35.45	39.95
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36				
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr				
39.10	40.08	44.96	47.88	50.94	52.00	54.94	55.85	58.93	58.69	63.56	65.39	69.72	72.59	74.92	78.96	79.90	83.80				
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54				
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe				
85.47	87.62	88.91	91.22	92.91	95.94	(98)	101.1	102.9	106.4	107.10	112.4	114.8	118.7	121.8	127.6	126.9	131.3				
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86				
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn				
132.9	137.3	138.9	178.5	180.9	183.9	186.2	190.2	190.2	195.1	197.1	200.5	204.4	207.2	209.0	(210)	(210)	(222)				
87	88	89	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118				
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Uuu	Uub	Uut	Uuq	Uup	Uuh	Uus	Uuo				
(223)	(226)	(227)	(257)	(260)	(263)	(262)	(265)	(266)	(271)	(272)	(277)	(284)	(296)	(288)	(298)	(?)	(?)				

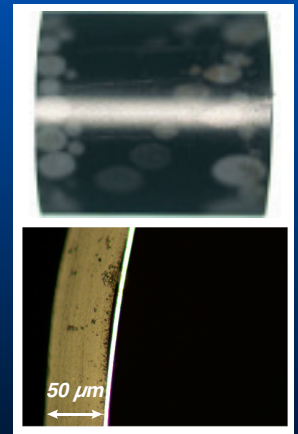
58	59	60	61	62	63	64	65	66	67	68	69	70	71
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
140.1	140.9	144.2	(147)	150.4	152.0	157.3	158.9	162.5	164.9	167.3	168.9	173.0	175.0
90	91	92	93	94	95	96	97	98	99	100	101	102	103
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
232.0	(231)	(238)	(237)	(242)	(243)	(247)	(247)	(249)	(254)	(253)	(256)	(254)	(257)

We seek opportunities to expand elements to meet ICF target needs

FeK shell target

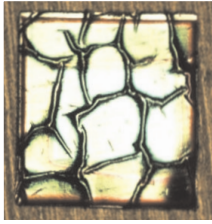
2 μm inner cylindrical metal coating

SS-304 (70 atom% Fe) coating

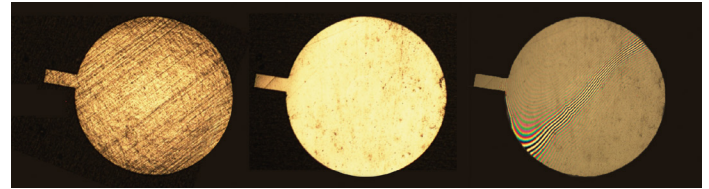


# COATING EXPERTISE

## BURIED LAYER OPACITY TARGETS



*Carbon microleaf / Si / CH targets*



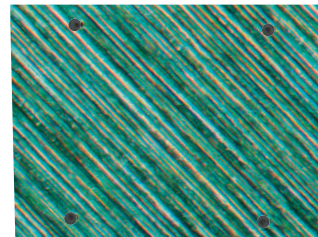
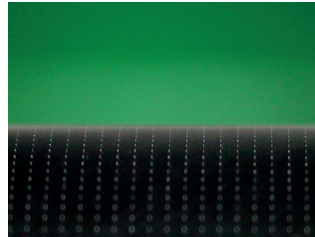
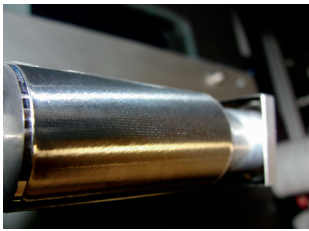
As fabricated

Polished

Surface Analysis

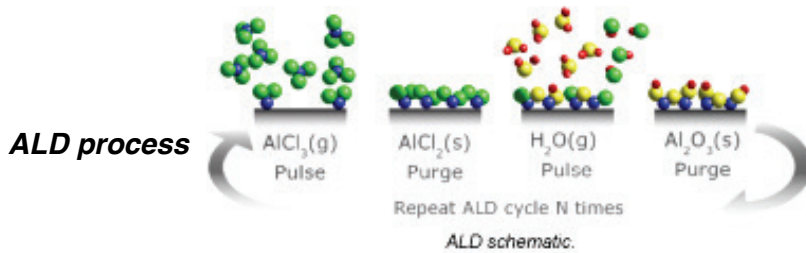
*Be/Au, Ti/Be Tampered Targets*

## THIN COATING MICRO-DOT TARGET

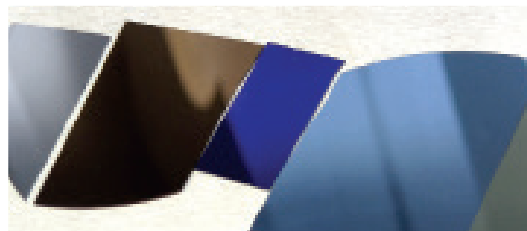


*Aluminum micro-dot target array on cylindrical substrate. Over 10,000 targets present on cylinder.*

## ATOMIC LAYER DEPOSITION



**Fabricated  
ALD coating**



**Various ALD  
pinhole-free  
coated samples**

General Atomics Inertial Fusion Technologies produces a wide range of routine and “first-of-a-kind” components for experiments performed by scientists at the Laboratory for Laser Energetics (LLE), Lawrence Livermore National Laboratory (LLNL), Sandia National Laboratory (SNL), Atomics Weapons Establishment (AWE) and various universities. Examples of some opacity multi-layer targets fabricated for the ICF community are provided.



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