



**Partial List of ALD Processes 02/25/2019**

Type	Precursor 1	Precursor 2	Temperature (°C)
<b>Oxides</b>			
Al <sub>2</sub> O <sub>3</sub>	TMA	water	60 - 400
Al <sub>2</sub> O <sub>3</sub>	TMA	ozone	60 - 300
Al <sub>2</sub> O <sub>3</sub>	TMA	oxygen plasma	30 - 300
B <sub>2</sub> O <sub>3</sub> *	TMB	O <sub>3</sub>	100 - 200
CeO <sub>2</sub>	Ce(iPrCp) <sub>3</sub>	water	200 - 300
Co <sub>3</sub> O <sub>4</sub> *	CoCp <sub>2</sub>	O <sub>3</sub>	200 - 250
Fe <sub>2</sub> O <sub>3</sub> *	Fe <sub>2</sub> (tBuO) <sub>6</sub>	water	130 - 160
Fe <sub>2</sub> O <sub>3</sub> *	FeCp <sub>2</sub>	O <sub>3</sub>	200 - 300
Fe <sub>2</sub> O <sub>3</sub> *	FeCp <sub>2</sub>	oxygen plasma	200
Ga <sub>2</sub> O <sub>3</sub> *	TMG	oxygen	200C
HfO <sub>2</sub>	TDMAHf	oxygen plasma	150 - 250
HfO <sub>2</sub>	TDMAHf	water	95 - 275
In <sub>2</sub> O <sub>3</sub> *	InCp	water/O <sub>3</sub>	150
In <sub>2</sub> O <sub>3</sub>	TMIIn	water	200 - 250
IrO <sub>2</sub> *	IrEtCp(COD)	O <sub>3</sub>	200
MnO	Mn(EtCp) <sub>2</sub>	water	100 - 250
MgO	MgAMD	water	200 - 275
MgO	Mg(EtCp) <sub>2</sub>	water	130 - 275
NiO*	NiAMD	water	200 - 300
NiO*	NiCp <sub>2</sub>	O <sub>3</sub>	200 - 300
PO <sub>4</sub> *	Me <sub>3</sub> PO <sub>4</sub>	water	300
SiO <sub>2</sub>	BTBAS	oxygen plasma	150 - 300
SiO <sub>2</sub>	3DMAS	oxygen plasma	150 - 300
SiO <sub>2</sub>	SAM <sub>24</sub>	ozone	80 - 300
SiO <sub>2</sub>	TMA	t-butoxysilanol	75 - 250
SnO <sub>2</sub>	TDMASn	water	100 - 200
SnO <sub>2</sub>	TDMASn	hydrogen peroxide	100 - 200
SnO <sub>2</sub>	Tin Cyclic Stannylene	hydrogen peroxide	50 - 200
Ta <sub>2</sub> O <sub>5</sub>	TBTDET	water	150 - 350
TiO <sub>2</sub> *	TiCl <sub>4</sub>	water	80 - 300
TiO <sub>2</sub>	TDMATi	ozone	120 - 225
TiO <sub>2</sub>	TDMATi	water	80 - 225
TiO <sub>2</sub>	TDMATi	oxygen plasma	80 - 200
TiO <sub>2</sub> *	TTIP	water	150 - 250
V <sub>2</sub> O <sub>5</sub> *	VTIP	water	90 - 160
Y <sub>2</sub> O <sub>3</sub>	YAMD	water	150 - 280
Y <sub>2</sub> O <sub>3</sub>	Y(MeCp) <sub>3</sub>	water	200 - 280
ZnO	DEZ	water	110 - 200
ZrO <sub>2</sub>	TDMAZr	water	150 - 250
ZrO <sub>2</sub>	Zr FAMD	water	220 - 300

Type	Precursor 1	Precursor 2	Temperature (°C)
<b>Metals</b>			
Pt	Pt(MeCp)Me <sub>3</sub>	O <sub>2</sub>	200 - 300
Pt	Pt(MeCp)Me <sub>3</sub>	O <sub>3</sub>	150 - 300
Ni*	NiAMD	NH <sub>3</sub> /H <sub>2</sub>	160 - 220
Pd*	Pd(hafc) <sub>2</sub>	formalin	150 - 200
Ir	Ir(acac) <sub>3</sub>	O <sub>2</sub>	200 - 300
Co*	CoAMD	NH <sub>3</sub> /H <sub>2</sub>	150 - 250
Ru	Ru(EtCp) <sub>2</sub>	O <sub>2</sub>	250 - 300

Type	Precursor 1	Precursor 2	Temperature (°C)
<b>Nitrides</b>			
AlN	TMA	NH <sub>3</sub> plasma	200 - 300
WN <sub>x</sub>	BTBMW	NH <sub>3</sub> plasma	200 - 300
WN <sub>x</sub>	BTBMW	NH <sub>3</sub>	300 - 400
TiN	TDMATi	NH <sub>3</sub> plasma	150 - 300
TiN	TDMATi	NH <sub>3</sub>	250 - 300
NbN	TBTDEN	NH <sub>3</sub> plasma	200 - 300
SiN <sub>x</sub>	BTBAS	NH <sub>3</sub> plasma	200 - 300
Hf <sub>3</sub> N <sub>4</sub>	TDMAHf	NH <sub>3</sub>	200 - 250
NiN <sub>x</sub> *	NiAMD	NH <sub>3</sub> /H <sub>2</sub>	160 - 220

Type	Precursor 1	Precursor 2	Temperature (°C)
<b>Fluoride</b>			
MgF <sub>2</sub> *	Mg(THD) <sub>2</sub>	TaF <sub>5</sub>	230 - 250

Type	Precursor 1	Precursor 2	Temperature (°C)
<b>Sulfides</b>			
ZnS*	Diethylzinc	H <sub>2</sub> S	175 - 275
MoS <sub>2</sub> *	MoCl <sub>5</sub>	H <sub>2</sub> S	200 - 400

Type	Precursor 1	Precursor 2	Temperature (°C)
<b>MLDs</b>			
Alucone*	TMA	Ethylene glycol (EG)	100 - 150
hybrid alucone*	TMA	EG/Terephthaloyl chloride	150

**Nanolaminates**  
 Several different nanolaminates successfully demonstrated for specific applications:  
 YSZ (ytterium doped zirconium oxide) for fuel cell  
 PtAl<sub>2</sub>O<sub>3</sub> for resistive layer of MCP  
 Ru/TiN for Cu plating  
 FePO<sub>4</sub>\* for battery  
 WN/SiO<sub>2</sub> and WN/SiN for x-ray reflectivity  
 BiVO<sub>4</sub>\* for solar water splitting  
 NbTiN for superconductor