Atomic Layer Deposition

4D Labs system and recipes

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Cambridge NanoTech Fiji F200

From 4D Labs website:

The ALD system is equipped with a heated process chamber, remote plasma source, turbomolecular pump, and automated load lock for transferring substrates. The system is primarily intended for the deposition of a variety of thin films, including metals, oxides, and nitrides. Typical film thicknesses are monolayers up to tens of nanometers. Thicker films may be deposited but, since typical deposition rates are ~ 3-20 nm/h, deposition times will be several hours, at least.

Films available:

Currently, the following films may be deposited in the ALD system; however, it has the capability to deposit many other materials, which may be added on request. For additional information, please contact the tool owner.

Oxides: Al2O3, HfO2, SiO2, & ZnO.

Nitrides: AlN

Metals: Pt

Key features:

Highly conformable, well controlled layer by layer film deposition.

Multi-layer film stacks possible.

Aspect ratios of up to 450:1 in thermal mode or 20:1 in plasma mode are possible.

Substrates up to 200 mm in diameter and 6 mm thick can be accommodated.

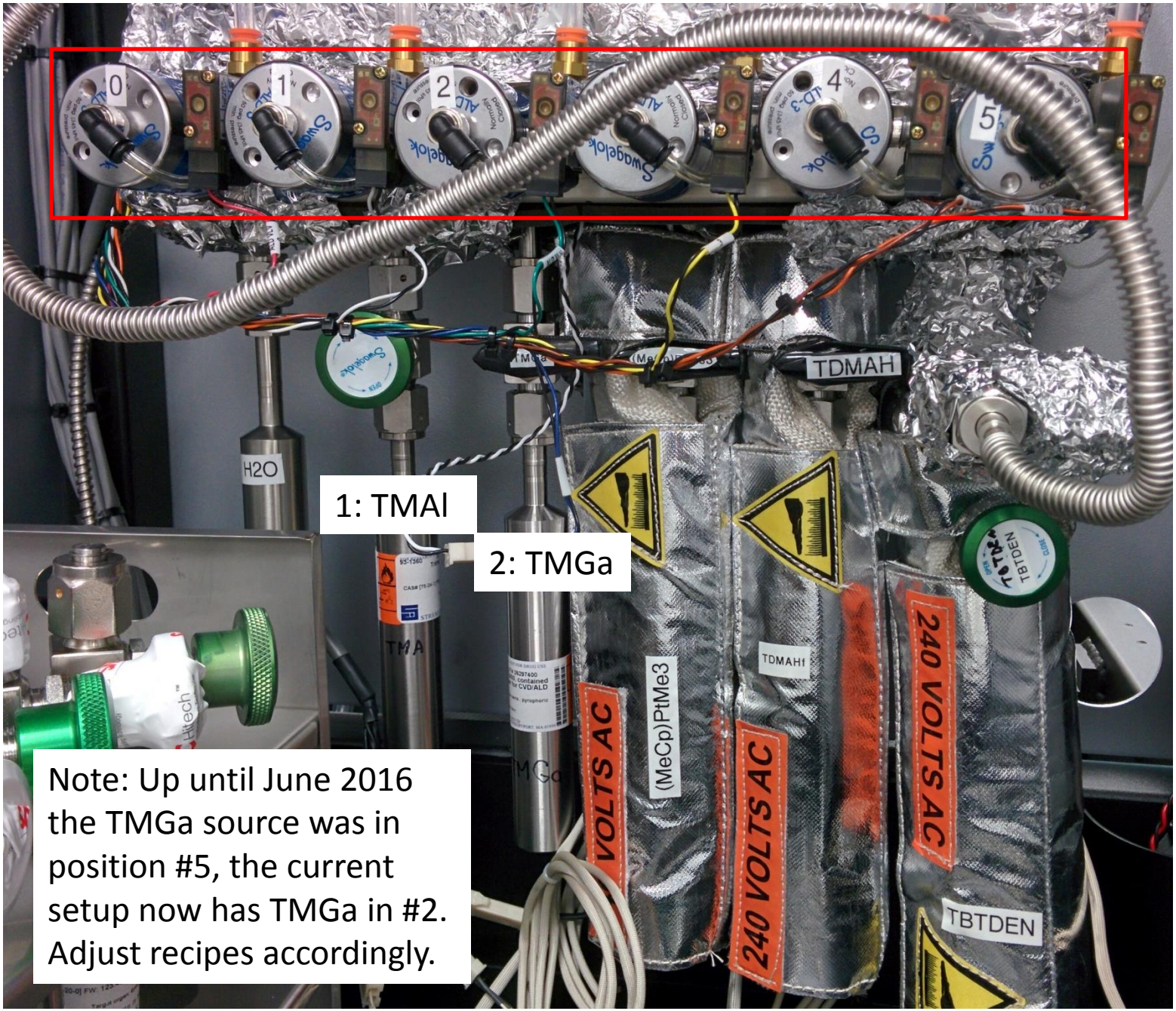
Substrates may be heated up to 400°C.

Process chamber turbomolecular pump provides a base pressure ~ 2 x 10^{-5} Torr.

Load lock chamber with automated transfer of substrates into the process chamber.

All depositions are performed from recipes.

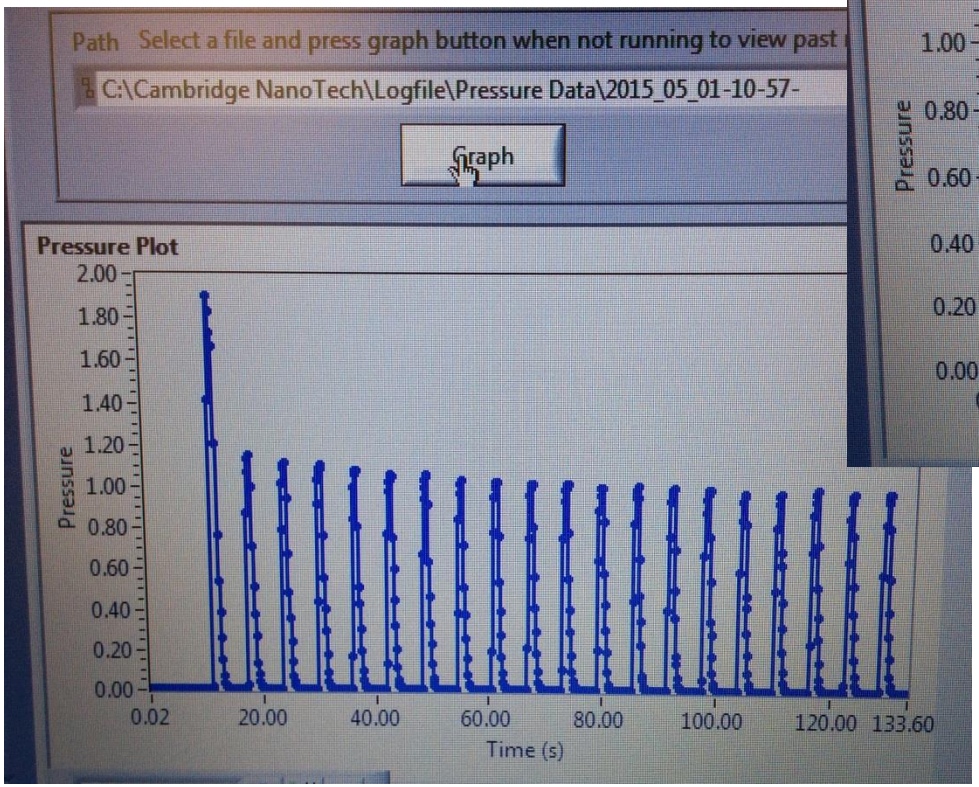
Available plasma gases are Ar, O_2, N_2, & H_2. Any combination of gases may be used simultaneously, with the exception that O_2 & H_2 cannot flow simultaneously.

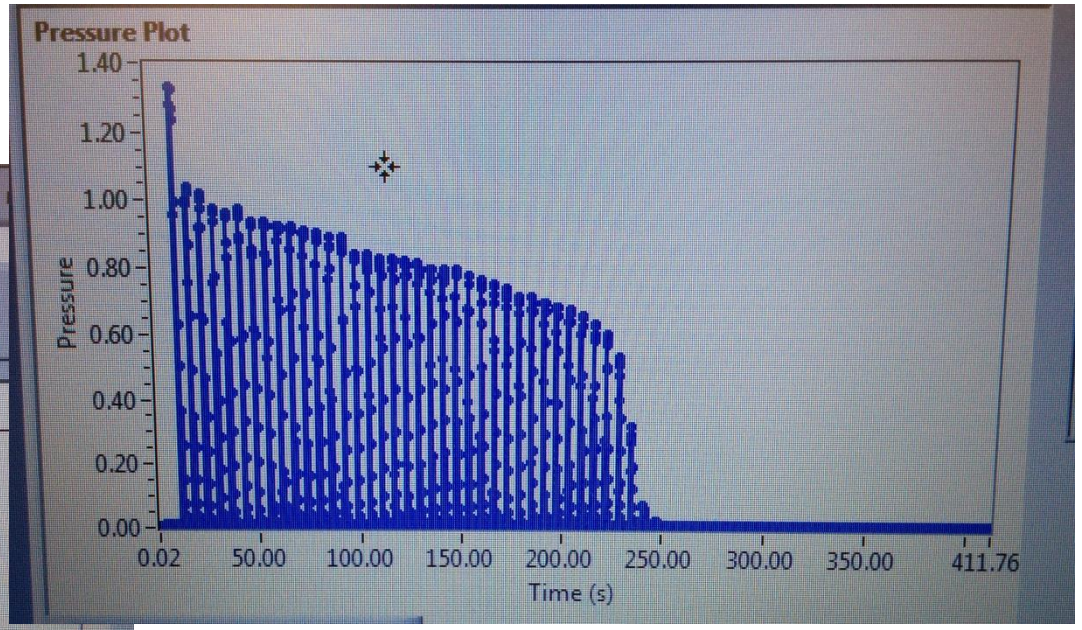

0
1
2
4
5
TDMAH
H2O
1: TMAl
2: TMGa
TMA
TMGa
(MeCp)PtMe3
TDMAHf
240 VOLTS AC
240 VOLTS AC
240 VOLTS AC
TBTDEN
TBTDEN
Note: Up until June 2016 the TMGa source was in position #5, the current setup now has TMGa in #2. Adjust recipes accordingly.

Ga_2O_3 – New TMGa source Sept 2015

Ga_2O_3 – Purge Headspace

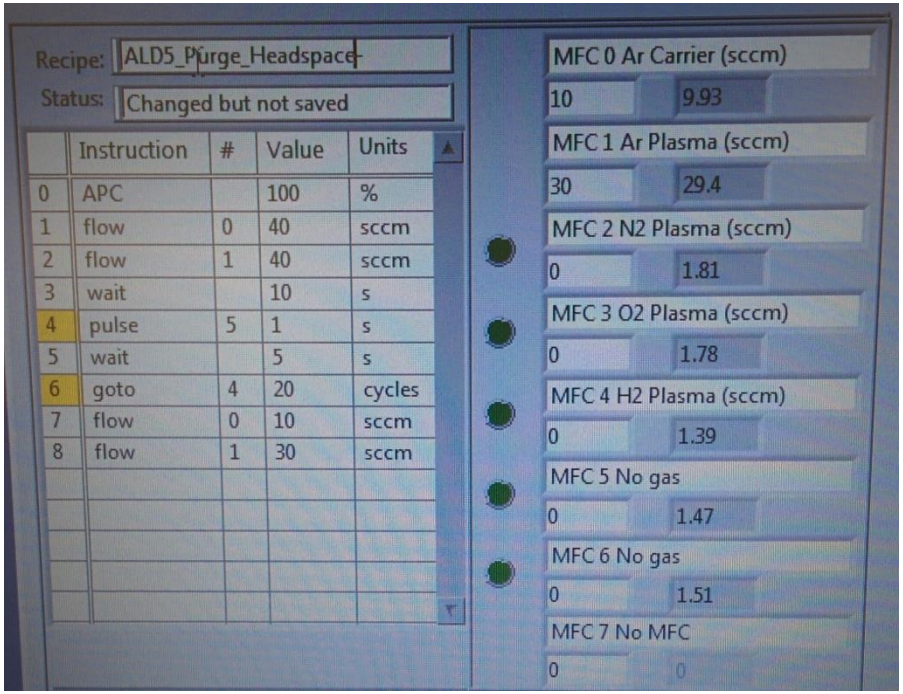
- Old purge headspace recipe, data from May 2015

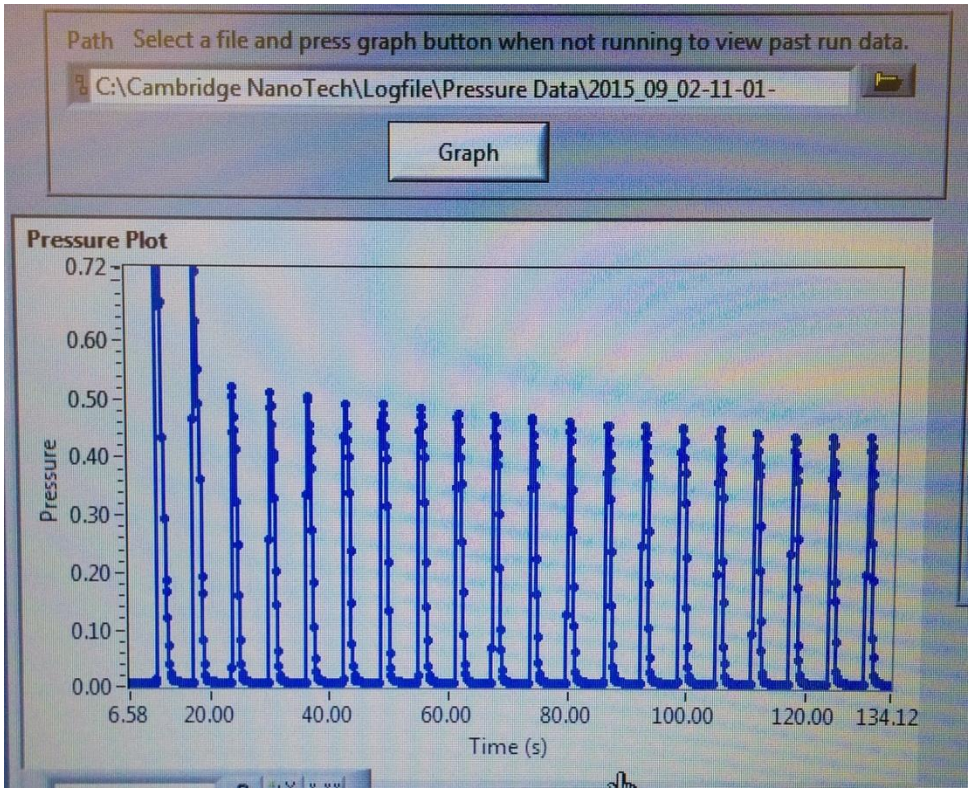




Ga_2O_3 – Purge Headspace

- New purge headspace pressure data from Sept. 2015 (right)
- Purge headspace recipe on file, not sure if it's old or new (left)





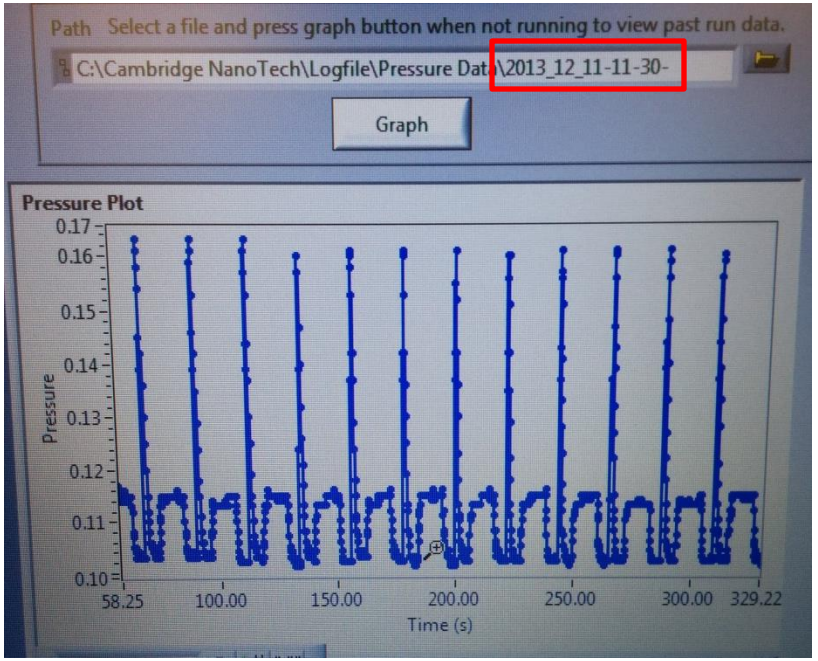
Ga_2O_3 – Growth

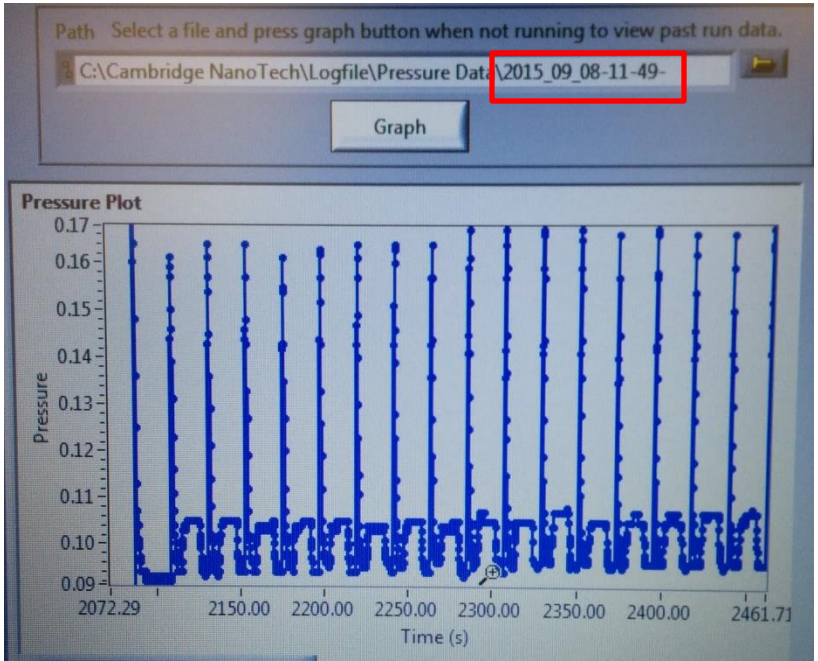
- Same recipe used every time, only # of cycles is changed

Recipe: Ga2O3_350C_TMGa_O2_Plasma

Status: Changed but not saved

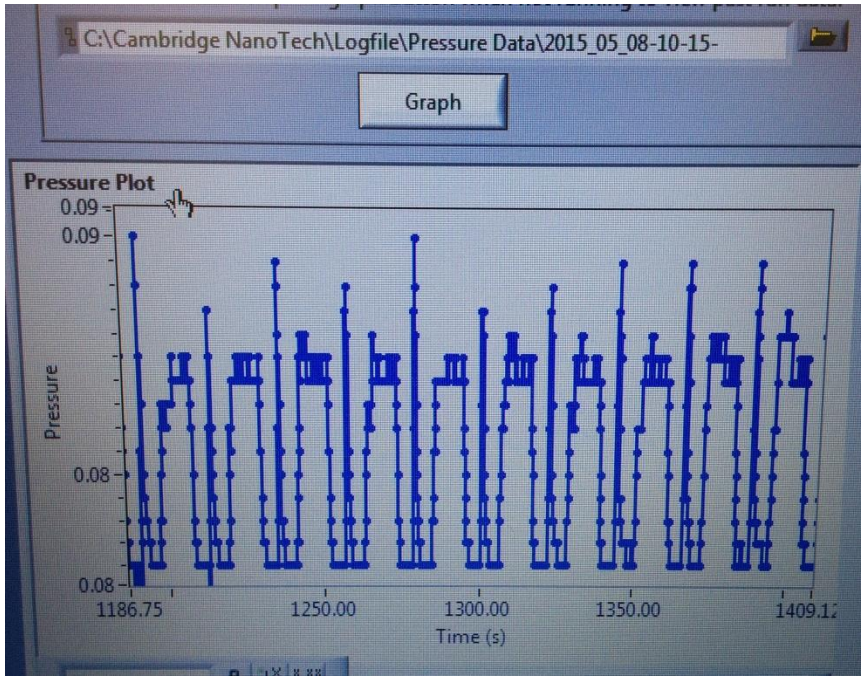
	Instruction	#	Value	Units
15	MFCvalve	3	1	
16	wait		20	s
17	pulse	5	0.015	s
18	wait		5	s
19	flow	3	25	sccm
20	wait		1	s
21	plasma		300	W
22	wait		10	s
23	plasma		0	W
24	flow	3	0	sccm
25	wait		5	s
26	goto	17	189	cycles
27	flow	0	10	sccm
28	flow	1	30	sccm



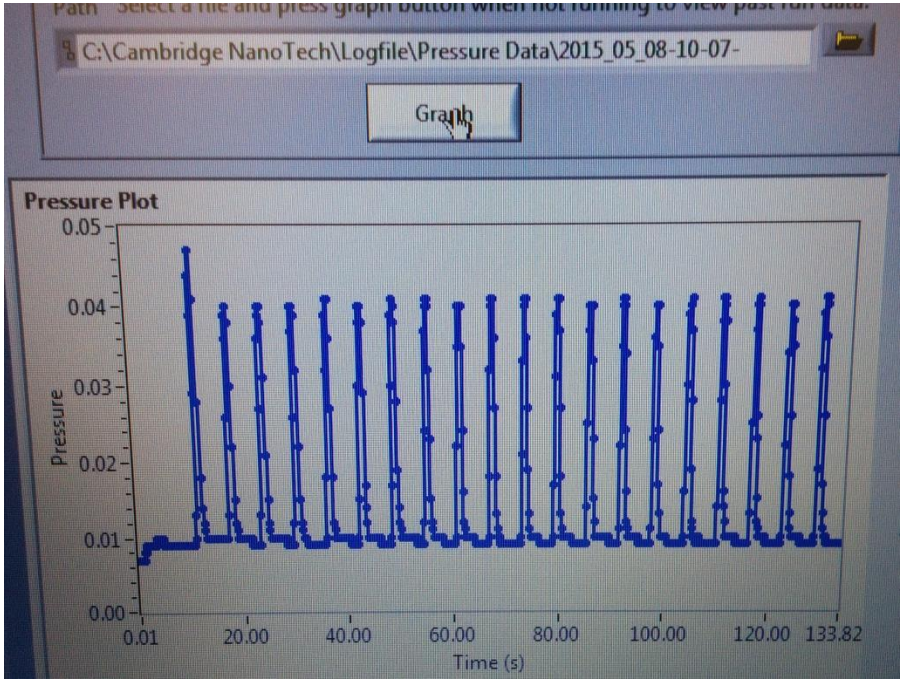


SiO_2 – Growth & Purge Headspace

Growth

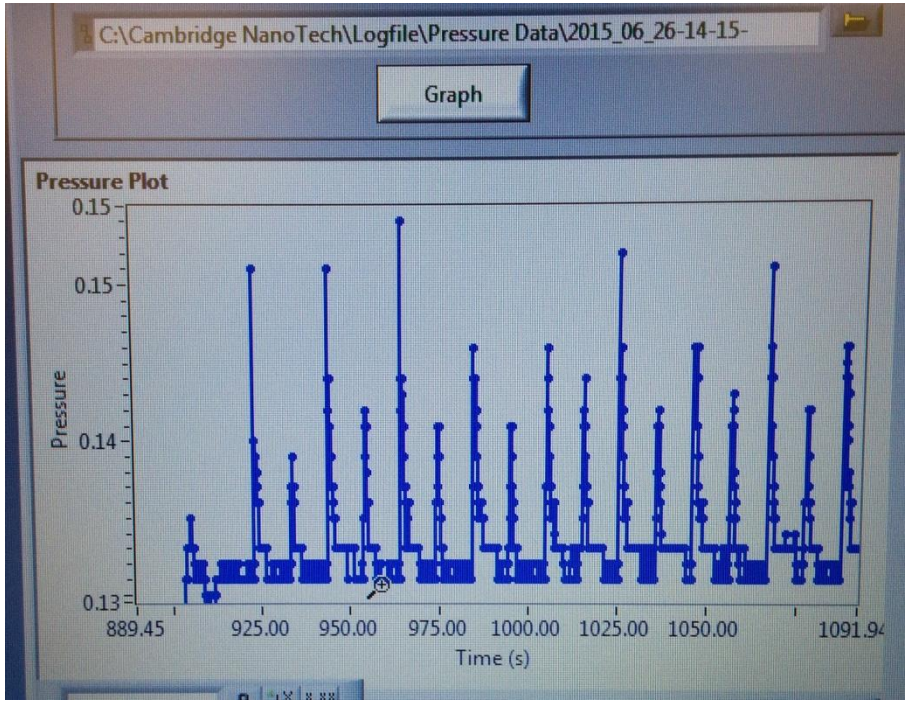


Purge Headspace

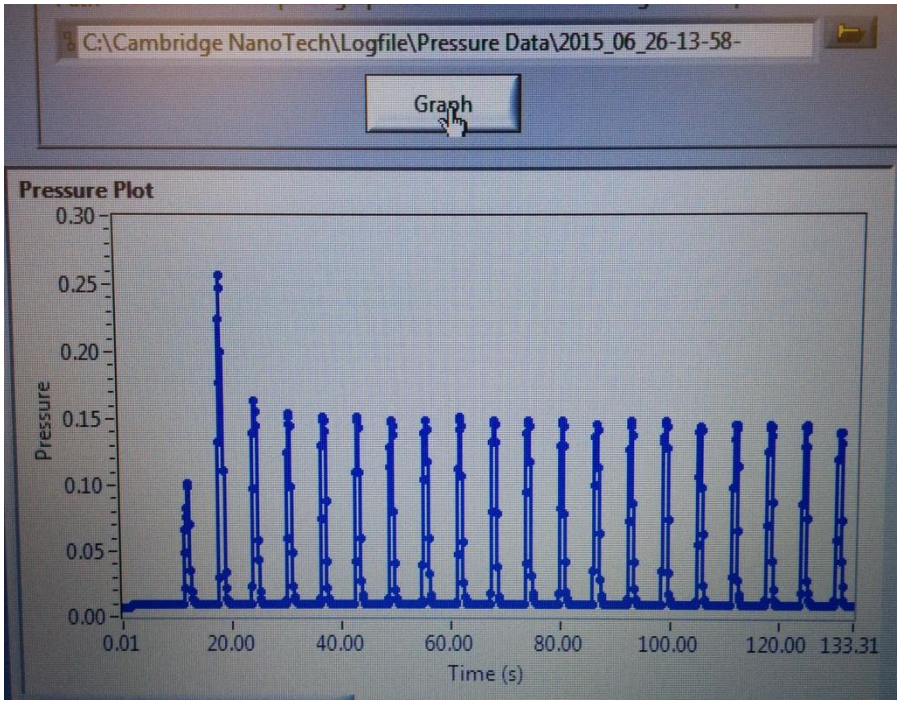


Al_2O_3 – Growth & Purge Headspace

Growth

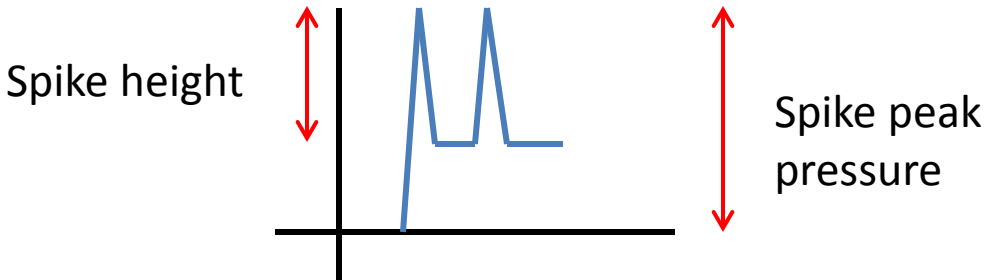


Purge Headspace



Summary

	Old Ga_2O_3	Ga_2O_3 (Sept 2015 ->)	Al_2O_3	SiO_2
Purge Headspace – spike height	1.0	0.46-0.52	0.14	0.03
Purge Headspace – spike peak pressure	0.01	0.01	0.15	0.04
Growth– spike height	0.06	0.07	0.02	0.015
Growth – spike peak pressure	0.16	0.16	0.15	0.09



ALD Runs:

Precursor	Date	Nominal Thickness (nm)	# of cycles	ALD ticket (hrs)	Cleanroom ticket (hrs)
TDMASi	April 8, 2015	8		5.58	1.67
TMGa	May 1, 2015	10	189	4.47	2.25
TDMASi	May 8, 2015	2.5	139	2.85	2
TMAl	June 26, 2015	8	90	2	1
TMGa	Sept. 8, 2015	8	94	2.33	1
TMGa	Sept. 16, 2015	8	93	2.32	1
TMGa	Dec. 21, 2015	40	465	5	3
TMAl	Jan. 13, 2016	40.5	450	3.17	1.25
TMAl	Jan. 18, 2016	8	90	1.5	0.5
TMAl	Jan. 21, 2016	2	22	1	0.5
TMAl	Jan. 21, 2016	4	45	1.33	0.5
TMGa	Feb. 2, 2016	20	233	2.25	0.75
TMAl	Feb. 23, 2016	2	22	1.5	0.5
TMAl	June 8, 2016	2	22	1.33	1

Deposition Rates For 4D Recipes

Film	Recipe	Precursor #1		Precursor #2	T_{chuck} °C	No. Cycles	Cycle Time (s)	Deposition	
		Material	T (°C)					nm/cycle	nm/h
AlN	AlN_200C_TMA_N2-H2-4D-20111123 *	TMA	RT	N_2-H_2	200	800	56.06	0.075	4.8
Al_2O_3	Al2O3_250C_TMA_H2O-4D-20111123	TMA	RT	H_2O	250	1,000	20.12	0.089	15.9
HfO_2	HfO2_200C_TDMAH_H2O_PRK_20111212	TDMAHf	75	H_2O	200	1,000	20.3	0.108	19.1
Pt	Pt_270C_MeCpPtMe3_O2-4D-20111202	$(MeCp)PtMe_3$	80	O_2	270	350	26.0	0.043	5.9
Pt	Pt_200C_MeCpPtMe3_O2-4D-20111202	$(MeCp)PtMe_3$	80	O_2	200	300	36.0	*0.036*	*3.6*
Pt	Pt_150C_MeCpPtMe3_O2-4D-20111202	$(MeCp)PtMe_3$	80	O_2	150	300	66.0	*0.036*	*2.0*
Pt	Pt_90C_MeCpPtMe3_O2-4D-20111202	$(MeCp)PtMe_3$	80	O_2	90	300	96.0	*0.036*	*1.4*
SiO_2	SiO2_250C_TDMASi_O2-4D-20111123	TDMASi	RT	O_2	250	1,200	19.1	0.018	3.4
SiO_2	Passivation-SiO2_250C_TDMASi_O2-4D-20111123	TDMASi	RT	O_2	250	1,400	19.1	0.018	3.4
ZnO	ZnO_250C_DEZ_H2O-4D-20111123	DEZ	RT	H_2O	250	800	20.12	0.130	23.3

* Do not use this recipe. Films degrade over time.
Deposition rate in regular face type have been measured at 4D Labs but rates in italics are based on Cambridge NanoTech standard recipes.