

# Standard Operating Manual

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## **Oxford OpAL ALD** **(ALD)**

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## 1. Picture and Location



Fig. 1: **Oxford OpAL ALD** is located at NFF Phase II Room 2240

## 2. Process Capabilities

### 2.1 Cleanliness Standard

Oxford OpAL ALD (ALD) is “Non-Standard” equipment for dielectric thin film deposition.

### 2.2 Available Deposition Materials

The following deposition materials are available.

Al<sub>2</sub>O<sub>3</sub>, ZrO<sub>2</sub>.

### 2.3 Wafer Size

The maximum wafer size is 150mm in diameter, 1mm thick. Wafer with any one dimension exceeds the maximum wafer size is not allowed to be put into the ALD.

### **3. Contact List and How to Become a User**

#### **3.1 Emergency Responses and Communications**

- Safety Officer: Mr. Wing Leong CHUNG 2358-7211 & 64406238
- Deputy Safety Officer: Mr. Man Wai LEE 2358-7900 & 9621-7708
- NFF Phase 2 Technicians: Mr. LI Ho ,or Mr. CHEN Yigong 2358 7896
- Security Control Center: 2358-8999 (24hr) & 2358-6565 (24hr)

#### **3.2 Training to Become a Qualified User**

Please follow the procedure below to become a qualified user of the ALD.

1. Read all materials on the NFF website concerning the ALD.
2. To register ALD operation training, logon to NFF Equipment Reservation System. Go to User Info page. Select Equipment Operation Training. Please follow the instructions on the web page.

## 4. Operating Procedures

### 4.1 System Description

In brief, Atomic Layer Deposition (ALD) is a thin film deposition method. During the deposition, the substrate is exposed to two or more chemicals (precursors) in vapour/gaseous form sequentially (not simultaneously). In each exposure, the precursor molecules react with the substrate surface in a self limiting way. That means the reaction will terminate once all the reactive sites on the surface are consumed. After exposures of all the precursors, one layer of the compound is formed.

Taking thermal ALD growth of  $\text{Al}_2\text{O}_3$  on silicon substrate as example, in our system a typical growth cycle consists of four steps.

#### (1) *TMA Dose*

TMA vapour is added to the chamber. TMA molecules then chemisorb onto the silicon surface until all reactive sites are occupied. Excess TMA molecules cannot adsorb to the TMA-reacted surface anymore.

#### (2) *TMA Purge*

All excess TMA and gaseous reaction by-product are purged out from the chamber.

#### (3) *Water Dose*

Water ( $\text{H}_2\text{O}$ ) vapour is added to the chamber. Water molecules react with the TMA-reacted surface and again until all reactive sites are consumed, forming one layer of  $\text{Al}_2\text{O}_3$ . Excess water molecules cannot adsorb to the  $\text{H}_2\text{O}$ -reacted surface anymore.

#### (4) *Water Purge*

All excess water and gaseous by-product are purged out from the chamber.

The cycle is repeated until the desired thickness is reached. In our system, the growth rate of  $\text{Al}_2\text{O}_3$  is  $\sim 1\text{\AA}/\text{cycle}$ .

### System Component Locations

Fig. 2 shows the locations of major system components.

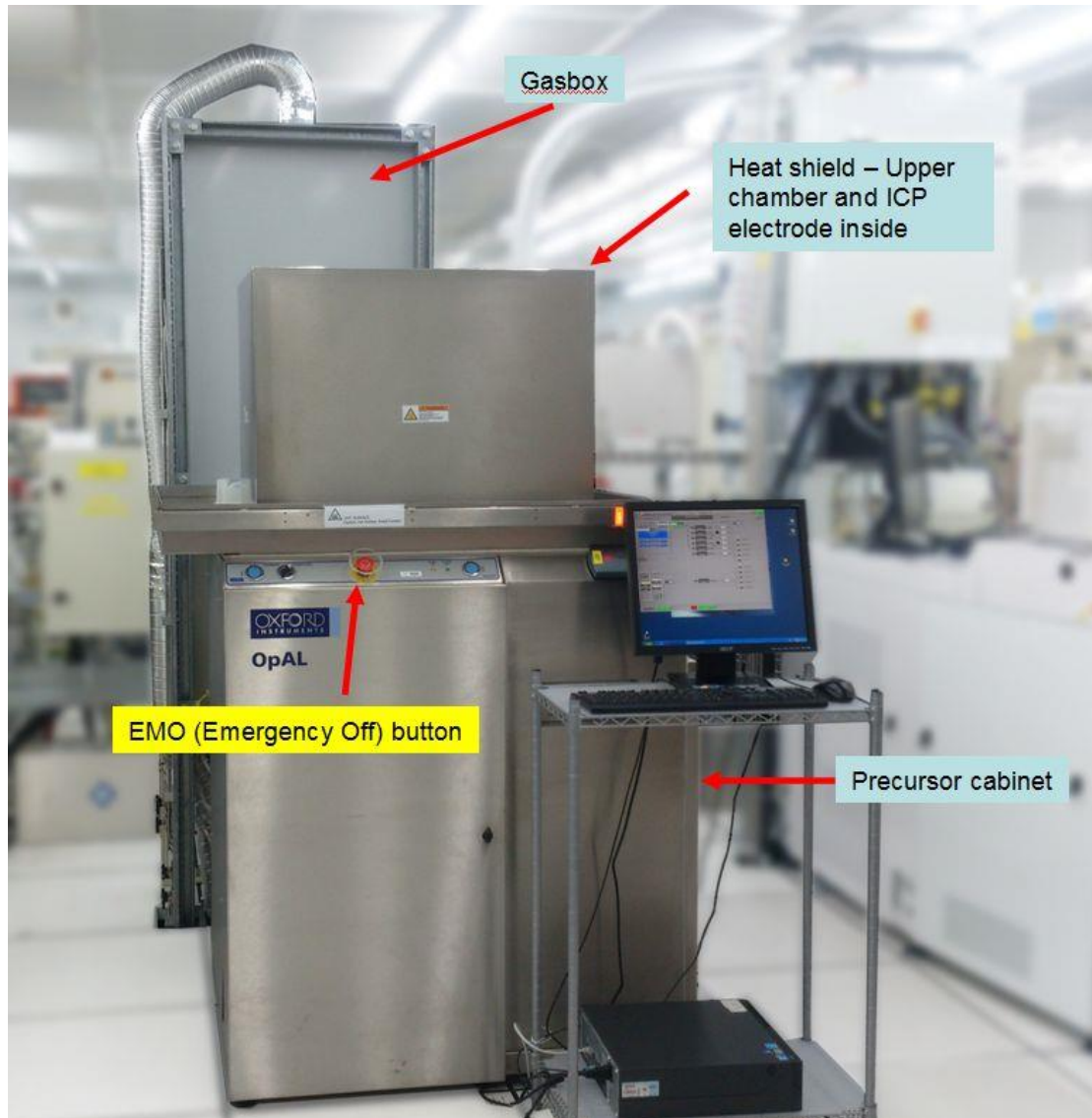


Fig. 2: System component locations

## Hazards

The precursors Trimethylaluminium (TMA) and Tetrakis(ethylmethylamino)zirconium (TEMAZ) used in ALD are hazardous liquid/vapour (highly flammable and corrosive). Exposure of RF frequency radiation can cause severe injury or burns if the system is not properly shielded. In addition, electricity, hot components, moving components, vacuum, compressed air, and etc in the ALD system can produce hazards. User must be aware of possible hazards associated with using the ALD.

## Emergency Stop Procedure

If an emergency condition is suspected, depress fully the Red Emergency Off (EMO) Button located on the system as shown in Fig. 2.

## 4.2 Important Cautions

- (1) If an equipment failure while being used, never try to fix the problem by yourself.  
Please contact NFF staff.
- (2) Make sure your wafers have been cleaned before entering the ALD.
- (3) Also make sure your wafer container and handling tweezers are clean.
- (4) Non-Standard does not mean you can put everything into the machine. Follow your process flow. Materials which are not mentioned in the process flow are NOT allowed to put into the ALD.
- (5) Processes which are not mentioned in the process flow are NOT allowed to be done in the ALD.
- (6) Please contact NFF staff in advance for the process of ZrO<sub>2</sub> growth.

(7) Remember to fill in the **Log Sheet**.

### 4.3 Initial system checks

(1) From the screen header of the control software, click on the field displayed “View\_Only”. The “Access Control” dialog is displayed. Enter “NFF” in both Name and Password data fields. Click on the **OK** button. The text displayed will change from “View Only” to “User”.

(2) From the screen header, select the **Process** menu, then the **Chamber 1**.

- Check the Process status field which is on left hand side of the text “IGNORE TOLERANCE”. The field displays **Ready** in green when there is no process running.
- Check that the Chamber Pressure is below 10mTorr.
- Check that the TABLE HEATER temperature is below 380°C.

(3) From the screen header, select the Utilities menu, then the Temperature. Check that the temperatures are set according to the Fig. 3. And the actual temperatures of all enabled heaters should be read within 2% fluctuation to the set values.



Set Pump Heaters

Zone Heaters

UpperChamber	<input checked="" type="checkbox"/> Enabled	
<input type="text" value="150"/>		149.5 C
LowerChamber	<input checked="" type="checkbox"/> Enabled	
<input type="text" value="150"/>		149.4 C
Int Pumping	<input checked="" type="checkbox"/> Enabled	
<input type="text" value="80"/>		80.5 C
Ext Pumping	<input type="checkbox"/> Disabled	
<input type="text" value="1"/>		3276.7 C
P1Z3(DuaVal)	<input checked="" type="checkbox"/> Enabled	
<input type="text" value="130"/>		131.7 C
P2Z1(Pot)	<input type="checkbox"/> Disabled	
<input type="text" value="20"/>		22.7 C
P2Z2(Intermed)	<input checked="" type="checkbox"/> Enabled	
<input type="text" value="110"/>		111.0 C
P2Z3(DuaVal)	<input checked="" type="checkbox"/> Enabled	
<input type="text" value="110"/>		111.4 C

Zone Heaters

P3Z1(Pot)	<input type="checkbox"/> Disabled	
<input type="text" value="20"/>		21.8 C
P3Z2(Intermed)	<input checked="" type="checkbox"/> Enabled	
<input type="text" value="70"/>		71.0 C
P3Z3(DuaVal)	<input checked="" type="checkbox"/> Enabled	
<input type="text" value="70"/>		68.9 C
P4Z1(Pot)	<input type="checkbox"/> Disabled	
<input type="text" value="20"/>		21.5 C
P4Z2(Intermed)	<input type="checkbox"/> Disabled	
<input type="text" value="20"/>		25.5 C
P4Z3(DuaVal)	<input checked="" type="checkbox"/> Enabled	
<input type="text" value="110"/>		111.3 C
ICP Gate Valve	<input checked="" type="checkbox"/> Enabled	
<input type="text" value="120"/>		118.3 C
Not Used	<input type="checkbox"/> Disabled	
<input type="text" value="1"/>		3276.7 C

Set Autotune

RESET Heater PLC

WarmStart\_PLC

Comms OK

Fig. 3 Heater presets

## 4.4 Wafer Loading

- (1) From the screen header, select the **System** menu, then the **Pumping**.
- (2) Check that the chamber pressure (Cm gauge) is below 10mTorr.
- (3) Click on **STOP** button, then the **VENT** button.

- (4) Wait until the process chamber is fully vented, the vacuum switch icon changes from green color to red color. At the front control panel of the machine, set the selection switch to CHAMBER UP position.

Warning – Do not attempt to open the process chamber lid if the vacuum switch icon in the screen is in green color.

- (5) Press both hoist buttons simultaneously. The chamber lid will raise and rotate.  
(6) When the chamber lid is fully raised and rotated, release both hoist buttons.

Warning – The process chamber and the substrate table are VERY HOT. DON'T touch.

Warning – Be very careful to avoid dropping small pieces into the holes and pumping port of the lower chamber.

- (7) Carefully place/remove the samples on/from the heater table.  
(8) At the front control panel of the machine, set the selection switch to CHAMBER DOWN position.  
(9) Press and hold one of the hoist buttons first. Then press another one for a very short time and release quickly. The chamber lid will lower and rotate a little bit.  
(10) Repeat pressing the hoist button for a very short time and release quickly so that the chamber lid will lower and rotate in a SLOW way and until the chamber lid is closed.  
(11) From the Pumping screen, click on **STOP** button, then **EVACUATE** button. The

dialog “Load Wafer or pump chamber” is displayed. Enter your project number NFFxxxx. Click on **OK** button. Wait until the chamber pressure is below 140mTorr.

- (12) From the screen header, select the **Process** menu, then the **Recipes**.
- (13) Click on **Load** button. The “Load Recipe – Overwrite current recipe:-----?” dialog is displayed. Click on **Yes** button. Then The “Load Recipe – Recipe Name” dialog is displayed. Highlight a recipe named “Pumping down xxxC” where xxx is the desired process temperature. Click on **OK** button.
- (14) Click on **Run** button to start the “Pumping down xxxC” recipe for chamber pump-purge. If the “RED ALERT – Cm Gauge Pressure Switch Over Pressure” dialog appears, click on **Accept** button, go back to Recipes page and then click on **Run** button again.
- (15) Wait for the chamber pump-purge to completion. The “YELLOW ALERT – Chamber End of process reached” dialog will be displayed. Click on **Accept** button.

## 4.5 Deposition

Warning – During the process running, if there is something abnormal or some mistake has been made, you can click on STOP button any time. But *NEVER* click on START button and PAUSE button.

Warning – Unless otherwise approved, DON'T run any process NOT listed in the sheet of list – Standard Recipes. This list is attached to the machine. For other process, contact NFF staff.

## NANOSYSTEM FABRICATION FACILITY (NFF), HKUST

- (1) Check that the Chamber Pressure is below 10mTorr.
- (2) Check that the actual TABLE HEATER temperature is stabilized at the desired value.
- (3) Check that the Process status field is displayed as Ready.
- (4) From the screen header, select the **Process** menu, then the **Recipes**.
- (5) Click on Load button. The “Load Recipe – Overwrite current recipe:-----?” dialog is displayed. Click on **Yes** button. Then The “Load Recipe – Recipe Name” dialog is displayed. Highlight the required recipe. Click on **OK** button to load the recipe.
- (6) Click on **Run** button to start the deposition process.
- (7) Wait for the process to completion. The “YELLOW ALERT – Chamber End of process reached” dialog will be displayed. Click on **Accept** button.
- (8) Please follow the steps in “4.4 Wafer Loading” for removing the samples.
- (9) Before leaving, perform the “4.3 Initial system checks” again.