AlN deposition process in Sputter #2, PM1
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I. Overview of process

Wafers

Each device wafer must be preceded by a prep wafer to allow conditioning the system for proper AlN deposition. Prep wafers should be double-side polished Si wafers with resistivity equal to or greater than 1 ohm-cm (lower resistivity wafers lead to high AlN stress and flaking of deposited material inside the chamber). A prep process may be run once on each side of the prep wafer, but otherwise prep wafers cannot be re-used.

Prior to deposition

No photoresist in system!
Clean the device wafers (e.g., solvent clean or preferably nanostrip/BHF).
Edit the deposition time in the recipe **AlN_2013_sputter** to get the desired thickness.
Set the SAU to the appropriate value (e.g., 25 Ohm); this controls film stress.
Load alternating prep and device wafers in the appropriate cassette slots.

Deposition

Run the sequence **AlN_2013**. This recipe alternates between depositing on the prep wafers using the prep recipe (AlN_2013_prep, slots 4n+2) and depositing on the device wafers using the deposition recipe (AlN_2013_dep, slots 4n+4).

II. Description of recipe sequence

Recipes must not be modified other than adjusting the deposition time!

1. **AlN_2013_prep** includes an Al target clean (**AlN_2013_clean**) and target poisoning step (**AlN_2013_poison**). The clean step cleans the sputter target, leaving a fresh Al surface. The poison recipe coats the sputter target surface with a fresh AlN layer. This recipe must be run on a prep wafer prior to each AlN deposition on a device wafer.

2. **AlN_2013_dep** includes a heat step (**AlN_2013_preheat**) followed immediately by the AlN deposition (**AlN_2013_sputter**). Heating uses an external lamp to warm the substrate holder and wafer; there is no thermometer on the substrate holder, so this step depends on time and on the cleanliness of the chamber window. The sputter step deposits AlN on the device wafer. Edit the deposition time in **AlN_2013_sputter** to deposit the desired thickness of AlN on the device wafers. As of November 2013, 475 seconds deposits 330 nm of AlN on SiO_2. The deposition rate may change during long depositions.

3. Film stress can be controlled with the Stress Adjustment Unit (SAU), also known as the "resistor box." Using different substrates has a significant effect on the stress and requires separate tuning of the SAU value. Using a setting of 10 ohms or lower

significantly weakens the AlN 002 XRD peak. As of October 2013, the default value is 25 ohms, which gives low tensile stress (< 200 MPa) when sputtering on SiO_2.

V. Important reminders and requirements

Record all depositions in the log book. For the power, current, and voltage readings, refer to the display on the power supply in the rack. For the pressure during the run, record the capacitance vacuum gauge (CVG) value from the computer. If possible, record the data 60 s into the deposition.

Only deposit AlN using the AlN_2013 sequence.

Do not change any of the AlN_2013 recipes except for the deposition time in AlN_2013_sputter. If you would like to change other deposition parameters, consult with cleanroom staff. Note that prolonged operation at high power can damage the system permanently.

The prep wafer must be a clean, unprocessed Si wafer with resistivity at least 1 ohm-cm. Low resistivity wafers result in very compressive films that can flake.

A prep wafer may be used twice, once on each side. Do not reuse wafers more than this, as film stress mismatches can also cause flaking.

Do not run any sputter recipes in PM1 without a wafer in the chamber. Otherwise the chamber window will become dirty, disabling the heater.

No photoresist is permitted in PM1.

IV. Recipe parameters (11/2/2013)

Recipes:

AlN_2013_clean: 15 sccm Ar, 5 kW, 100 s
AlN_2013_poison: 8 sccm Ar, 20 sccm N2, 3 kW, 30 s
AlN_2013_preheat: 400 C, 40 s
AlN_2013_sputter: 4.5 sccm Ar, 18 sccm N2, 3.5 kW, [475 s for 330 nm], heat 400 C for first 40 s

Flows:

AlN_2013_prep: AlN_2013_clean; wait 60 s; AlN_2013_poison; wait 200 s
AlN_2013_dep: AlN_2013_preheat; AlN_2013_sputter

Sequence:

AlN_2013: AlN_2013_prep (slots 4n+2); AlN_2013_dep (slots 4n+4)

IV. Results & Consistency

The results we get for the recipe above depend on the age of the sputter target and its history of use. The deposited thickness for fixed time can vary by 5-10% depending on target history, but tends to be much more consistent for deposition runs close in time to one another. The optimal SAU resistor setting can vary over a range of 5-10 ohms, depending again on target history and on specific substrate composition and resistance, but seems again to be more consistent than that for runs on identical substrates close in time to one another.

A typical result is as follows:

Substrate: 100 mm 10 kΩ-cm Si <100> with 3 micron wet/thermal SiO_2
Recipe: As above, deposite for 495 s with SAU resistance R = 22.5 Ω
Thickness: 342 nm
Thickness variation: (max - min) / mean = 1.8%
Stress: +150 (edge) to +490 MPa (center), mean +320 MPa
XRD: AlN 002 FWHM 2.45 degrees