# FABRICATION OF MOS CAPACITOR USING $AL_2O_3$

# WHY WE USE $AL_2O_3$ INSTEAD OF ZNO IN MOS CAPACITORS?

| FACTORS | $Al_2O_3$ | ZNO |
|---|---|---|
| DIELECTRIC CONSTANT | ~9 | ~8-9 |
| BAND GAP | ~8.8eV(VERY HIGH) | ~3.3ev(LOWER) |
| LEAKAGE CURRENT | VERY LOW | HIGHER |
| THERMAL STABILITY | **VERY HIGH** | **LOWER,ZNO DECOMPOSES >500'C** |
| INTERFACE WITH Si | EXCELLENT | POOR |
| CHEMICAL STABILITY | VERY STABLE | LESS STABLE |
| DEFECT DENSITY | LOW AFTER ANNEALING | HIGH |

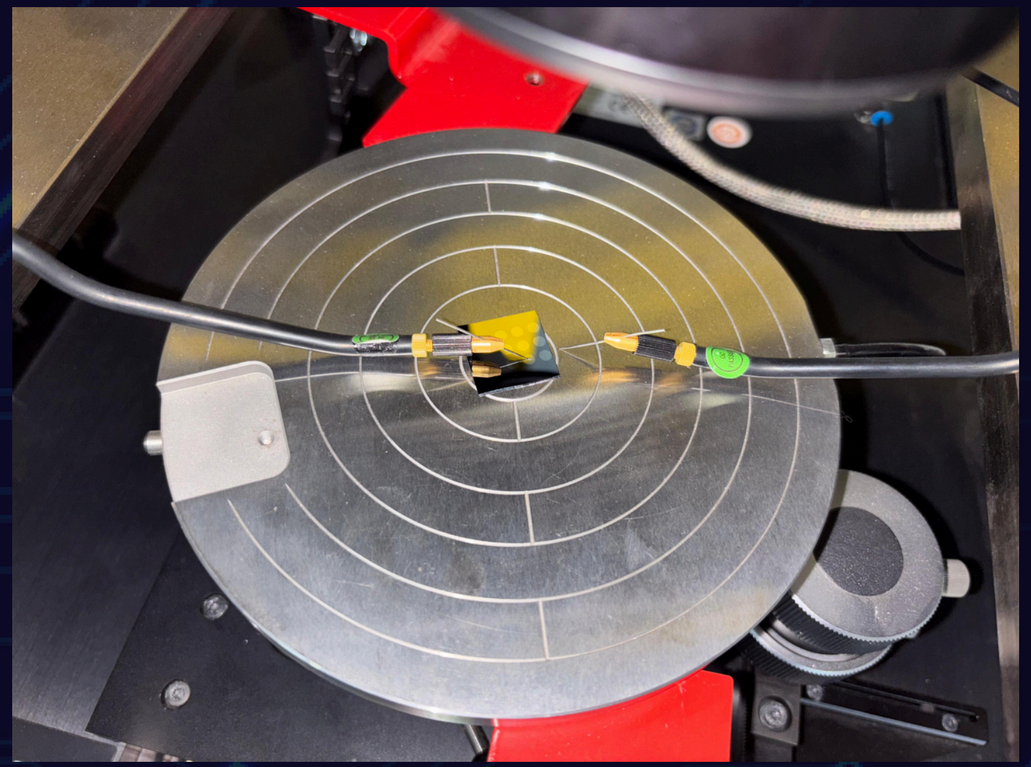
# FABRICATION OVERVIEW

01 CUTTING AND CLEANING

02 DEPOSITION

- RF SPUTTERING ( $Al_2O_3$ )
- THERMAL DEPOSITION (Al)

03 CHARACTERIZATION



# 1. CUTTING AND CLEANING

- CUT THE Si WAFER USING DIAMOMD CUTTER.
- CLEAN THE WAFER USING FOLLOWING STEPS:
  - RINSE IN DI WATER FOR 5min.
  - DIP IN 3:1 SOLUTION OF H2SO4/H202(EX. 40ml AND 13.33ml RESPECTIVELY) AND HEAT AT 120'C FOR 10min.
  - RINSE IN DI WATER AGAIN(JUST DIP IT FOR 30sec).

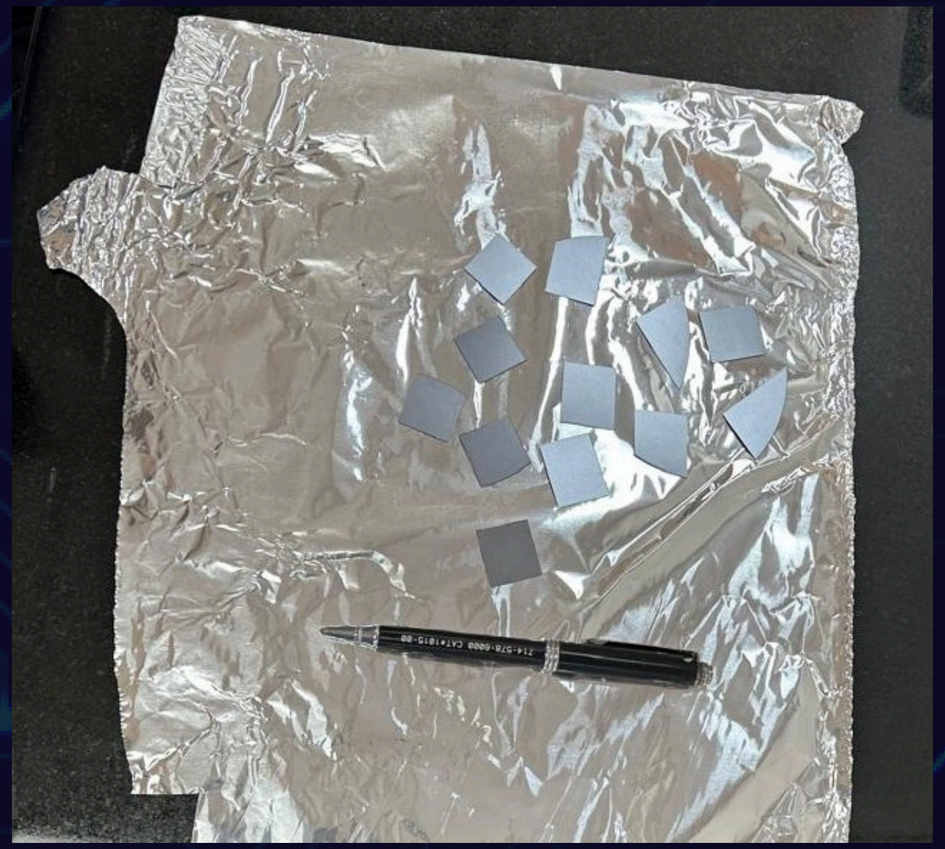


FIG: Si WAFER AFTER CUTTING

# 1. CUTTING AND CLEANING

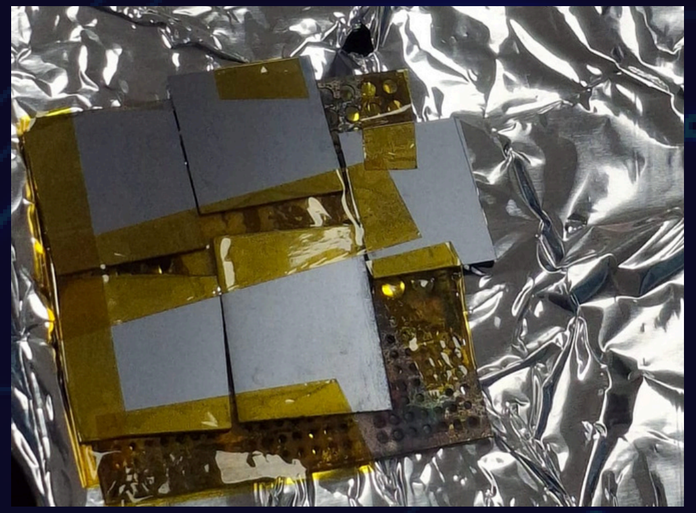
- DIP IN 7:1:2 SOLUTION OF DI WATER/NH4OH/H2O2 AND HEAT AT 85'C FOR 10min. (RCA1).
- DIP IN 7:1:2 SOLUTION OF DI WATER/HCL/H2O2 AND HEAT AT 85'C FOR 10min. (RCA2).
- DIP IN 1:24 SOLUTION OF HF/DI WATER FOR 5min.

FIG: AFTER CLEANING

# 2. DEPOSITION

## A. RF SPUTTERING TO DEPOSIT $AL_2O_3$

- FIX SI-WAFER ON SUBSTRATE HOLDER USING CRYPTON TAPE.
- CREATE VACCUM USING ROTARY AND TURBO PUMP.
- PLACE IN MACHINE AND SET PRESSURE UPTO 10^-6 FOR 40-45MIN.
- THEN SLOWLY INCREASE O2(OXYGEN) UPTO 15SCCM.



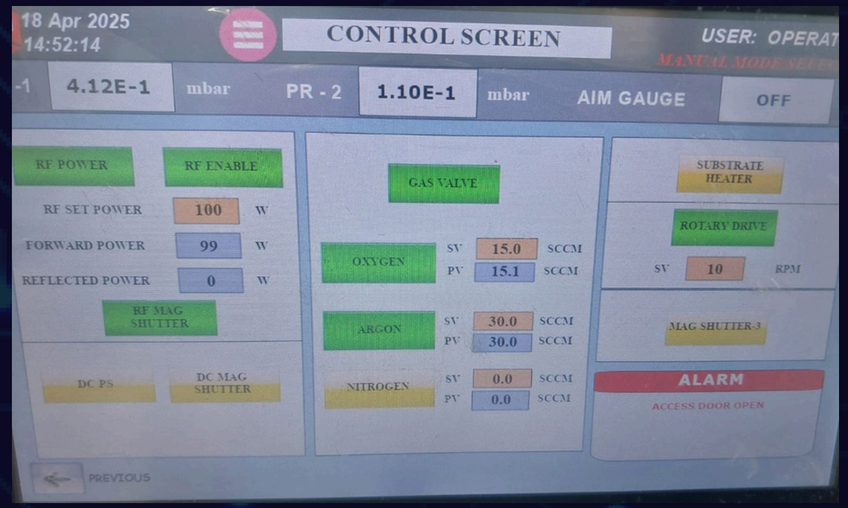



FIG: AUTO500 DISPLAY SCREEN

# 2. DEPOSITION

## A. RF SPUTTERING TO DEPOSIT $AL_2O_3$

- INCREASE RF POWER TO 100 watt TILL REFLECTED POWER WILL BE 0.
- FLOW ARGON GAS AS SAME AS OXYGEN UPTO 30sccm(IT CREATES MAGENTA COLOR FOR 40-45min.
- TURN OFF THE SHUTTER AND DECREASE THE POWER SLOWLY TO 0 WATT.
- SIMILARY DECREASE THE ARGON AND OXYGEN GAS PRESSURE UPTO 0sccm.

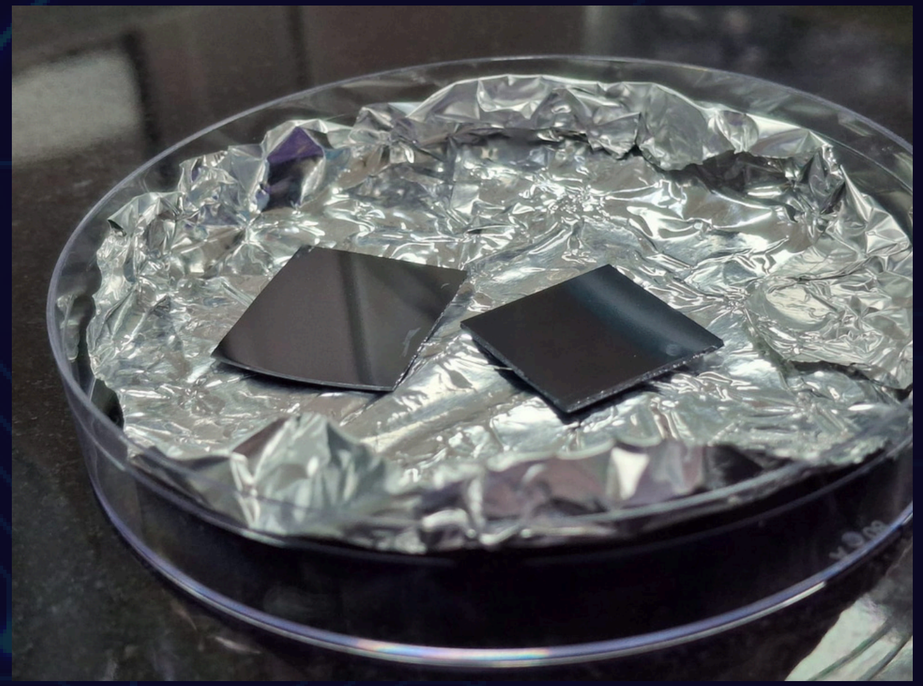


FIG: AFTER AL2O3 DEPOSITION

# 2. DEPOSITION

## B. THERMAL DEPOSITION (TO DEPOSIT AL)

- PLACE Al PELLETS INTO TUNGSTEN BOAT(MAKE SURE SOURCE IS CLEAN).
- CLOSE VACUUM CHAMBER PROPERLY AND START THE VACUUM PUMP.
- PUMP DOWN TO HIGH VACUUM(~10^-6).
- THEN SLOWLY HEAT THE Al SOURCE.
- INCREASE THE CURRENT TO HEAT THE FILAMENT/BOAT.


FIG: THERMAL DEPOSITION DISPLAY SCREEN

# 2. DEPOSITION

## B. THERMAL DEPOSITION(TO DEPOSIT AL)

- SET THE DEPOSITION RATE TO 0.2ANGSTROM/SEC
- TURN OFF THE HEATING CURRENT GENTLY AFTER REACHING TARGET THICKNESS.
- LET THE SOURCE AND SAMPLE COOL DOWN.

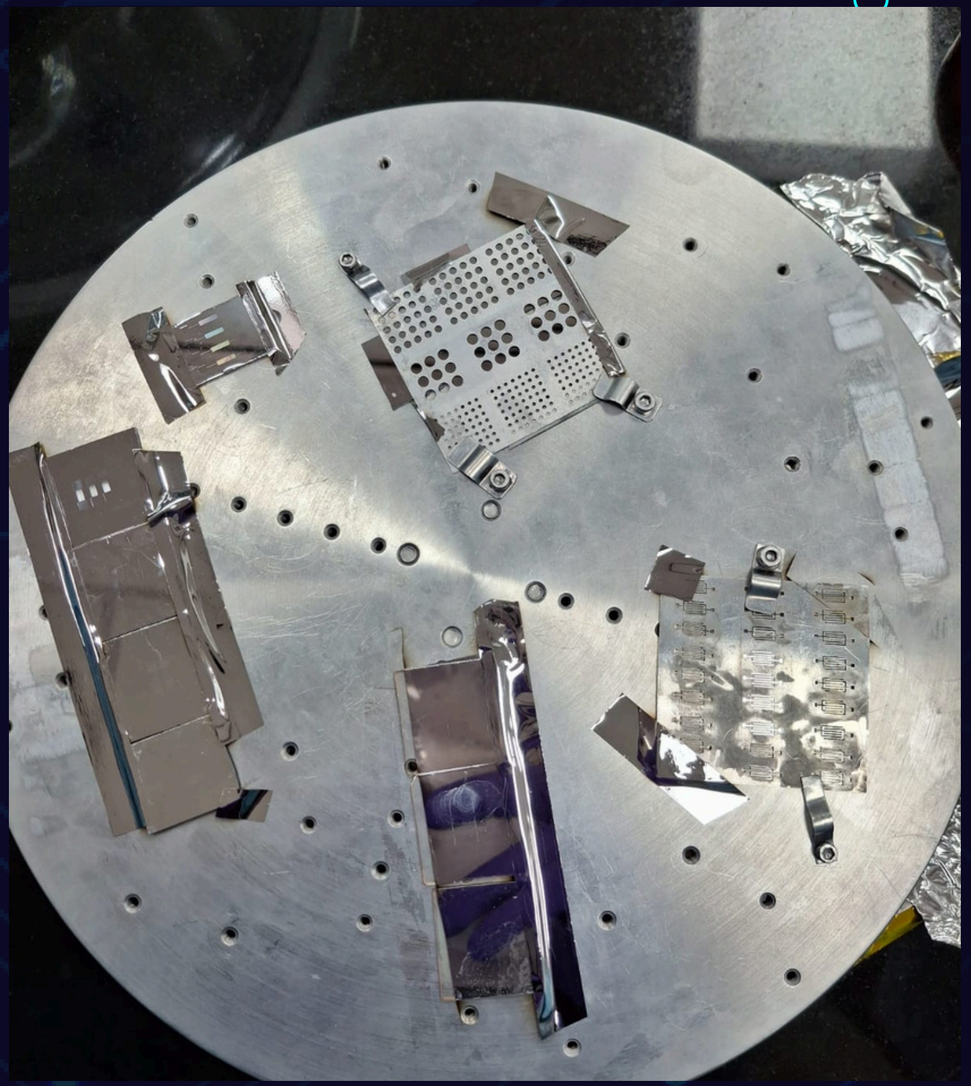
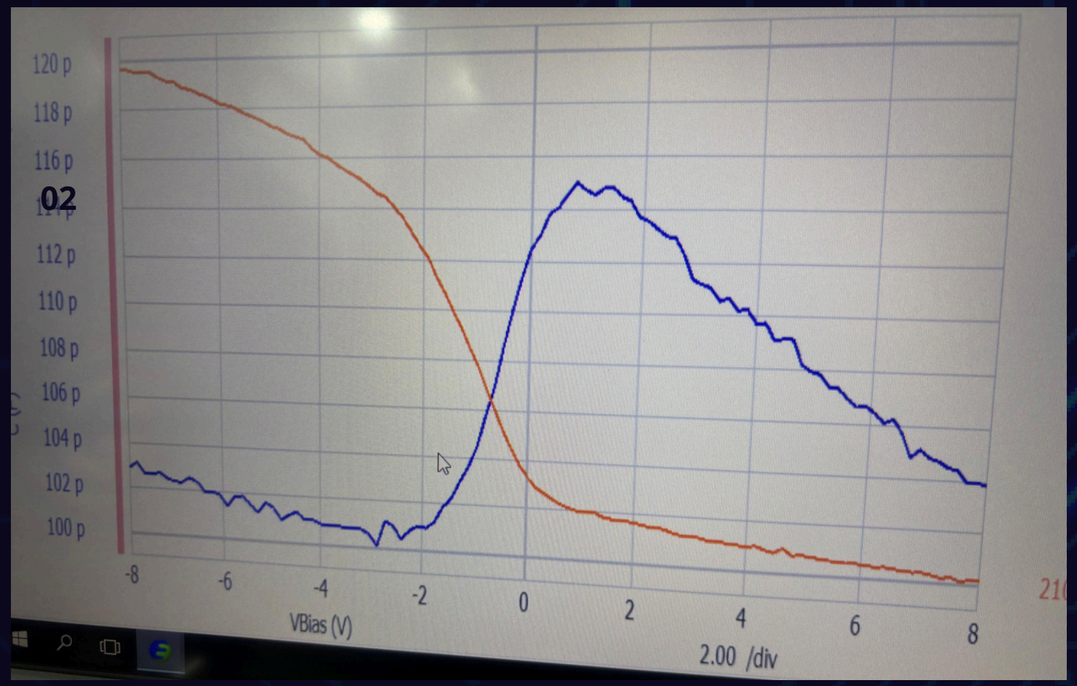


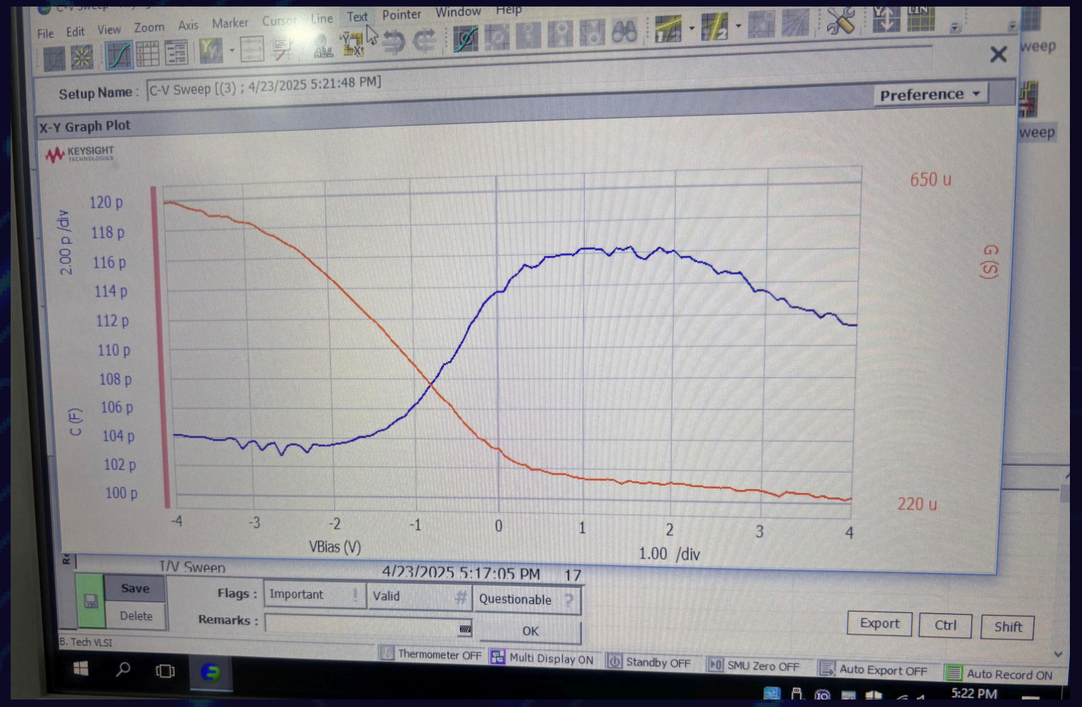
FIG: WAFER AFTER Al DEPOSITION

# 3. CHARACTERIZATION

THE C-V CHARACTERIZATION OF THE MOS CAPACITOR WITH $AL_2O_3$ DIELECTRIC WAS CONDUCTED TO EVALUATE ITS ELECTRICAL PERFORMANCE. USING A SEMICONDUCTOR PARAMETER ANALYZER, WE APPLIED A BIAS VOLTAGE (V_BIAS) SWEEP FROM -4 V TO 4 V AT 100KHZ, MEASURING CAPACITANCE ACROSS ACCUMULATION, DEPLETION, AND INVERSION REGIONS. THE RESULTING C-V CURVE SHOWED A CAPACITANCE DROP FROM $3.5\times10^{-10}$ F TO $1.0\times10^{-10}$ F, INDICATING A WELL-DEFINED SI-$AL_2O_3$ INTERFACE. THE SHARP TRANSITION AND MINIMAL NOISE SUGGEST LOW INTERFACE TRAP DENSITY, WHILE THE DIELECTRIC CONSTANT OF 9.0 CONFIRMS $AL_2O_3$'S QUALITY, VALIDATING THE FABRICATION PROCESS FOR HIGH-PERFORMANCE APPLICATIONS.

# 3. CHARACTERIZATION



# CONCLUSION

- SUCCESSFULLY FABRICATED A MOS CAPACITOR USING AL2O3 AS THE GATE DIELECTRIC.
- AL2O3 PROVIDES HIGH DIELECTRIC CONSTANT,GOOD THERMAL STABILITY AND STRONG INTERFACE QUALITY WITH SILICON.
- FABRICATED DEVICES SHOWED:
    - LOW LEAKAGE CURRENT
    - GOOD CAPACITANCE VOLTAGE(C-V) CHARACTERISTICS
    - HIGH BREAKDOWN VOLTAGE
- AL2O3 IS A PROMISING ALTERNATIVES TO SIO2 FOR FUTURE SCALED-DOWN CMOS TECHNOLOGIES.
- FURTHER OPTIMIZATION(EG: DEPOSITION AND ANNEALING) CAN ENHANCE DEVICE PERFORMANCE AND RELIABILITY.

# THANK YOU