EFUG 2008 Maastricht, the Netherlands

Higher Resistivity Dielectric

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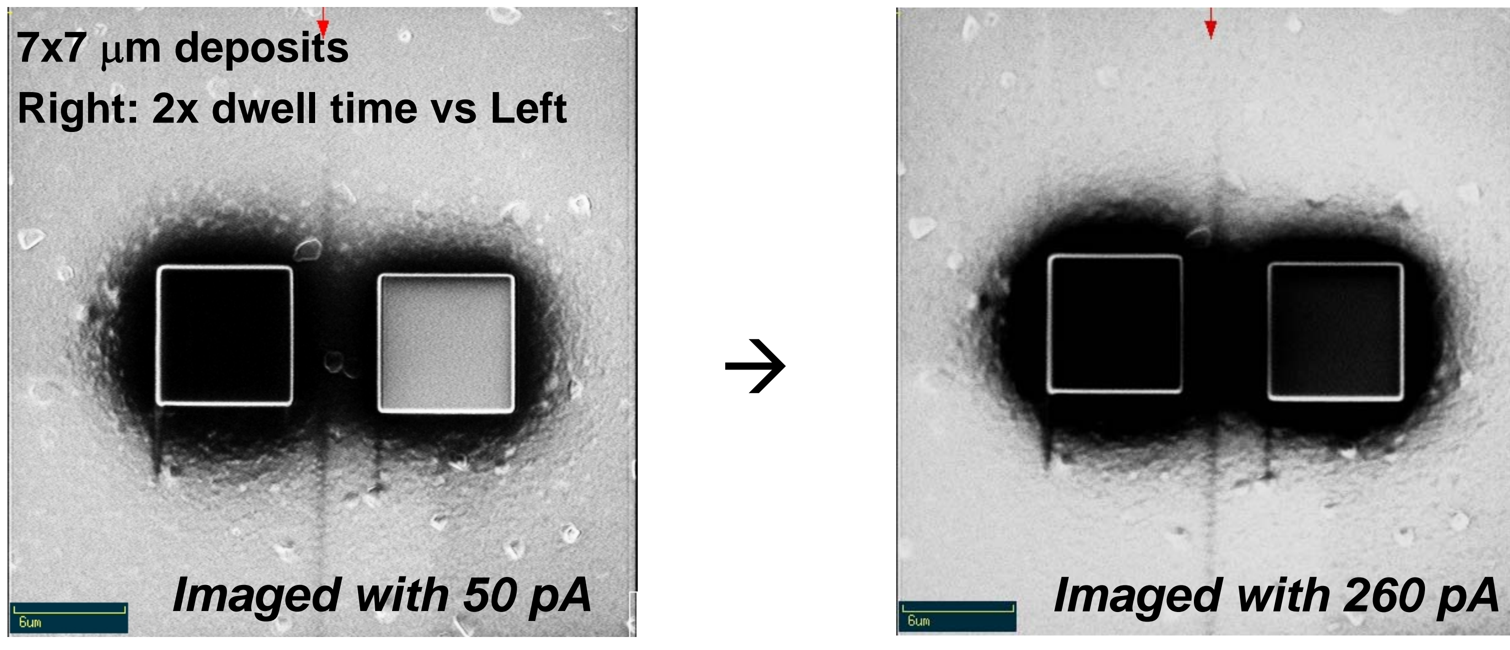
29 September 2008

Deposition Quality Control

- Insulator deposition quality controlled by beam scanning speed
  - Higher scan speed→ better insulator quality
- Deposited insulator darkness: a quality check
  - Insulator "Darkness" depends on imaging current
  - Higher the current density → the darker the insulator image



- All quality checks were performed with same 50 pA
  - Exceptions: depositions using low currents: 3 & 10 pA
  - Deposition current used but with higher magnification to maintain average current density

Deposition Stability

- For process stability, precursor surface accumulation rate is important.
  - Each frame should start no earlier than when precursor quantity saturates
  - Precursor accumulation rate α “residence time”
    - Average time a molecule sits on the surface before leaving
    - Function of precursor vapor pressure.
  - Residence time estimated from vapor pressure
  - Accordingly, refresh time = frame time

Optimized deposition conditions

- Insulator deposited: smooth & without gaps/spaces
  - Pixel & line overlap important
  - Dwell time t: $\leq$ 100 ns, for continuous beam scanning
  - Single line deposition width confirmed experimentally for each current
- Precursor Pressure low 10^{-5} Torr;

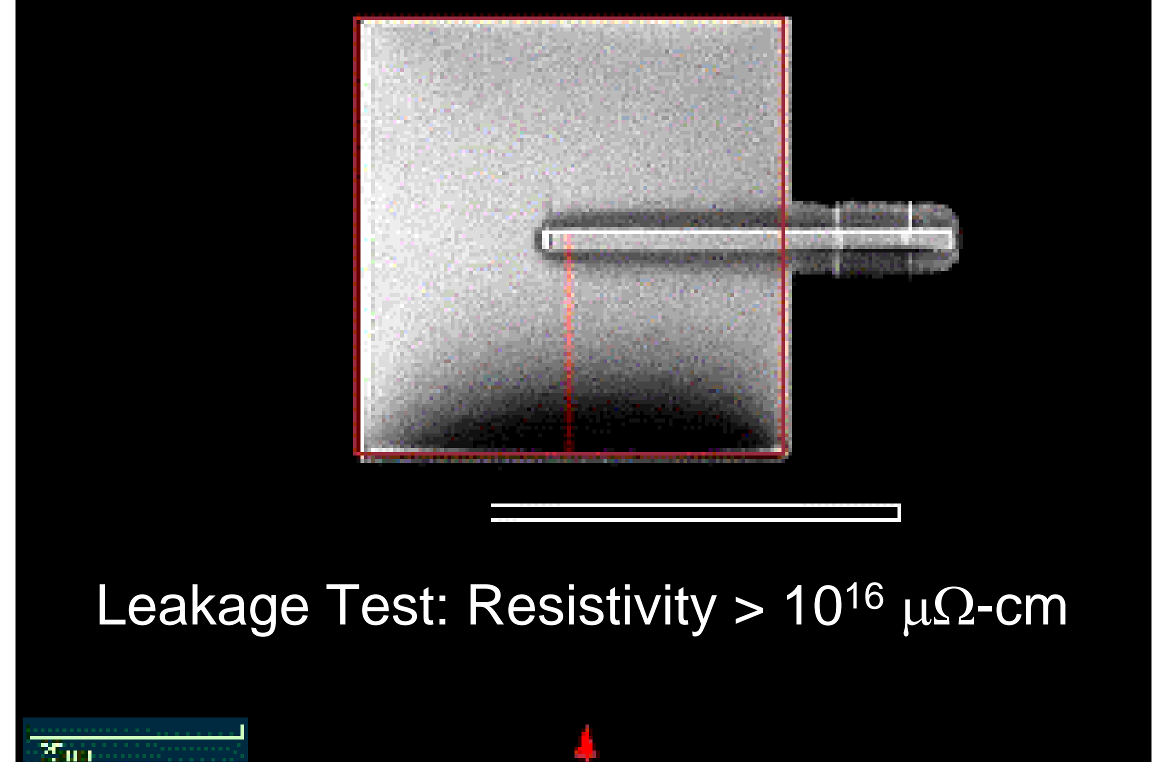
Depositions

Beam Current	3 pA 0.5 x 0.5 μm	10 pA 1.5 x 1.5 μm	50 pA 3 x 3 μm	260 pA 7 x 7 μm	1000 pA 15 x 15 μm	4000 pA 30 x30 μm
Plan view						
Tilted view						

Insulator Deposition test structure

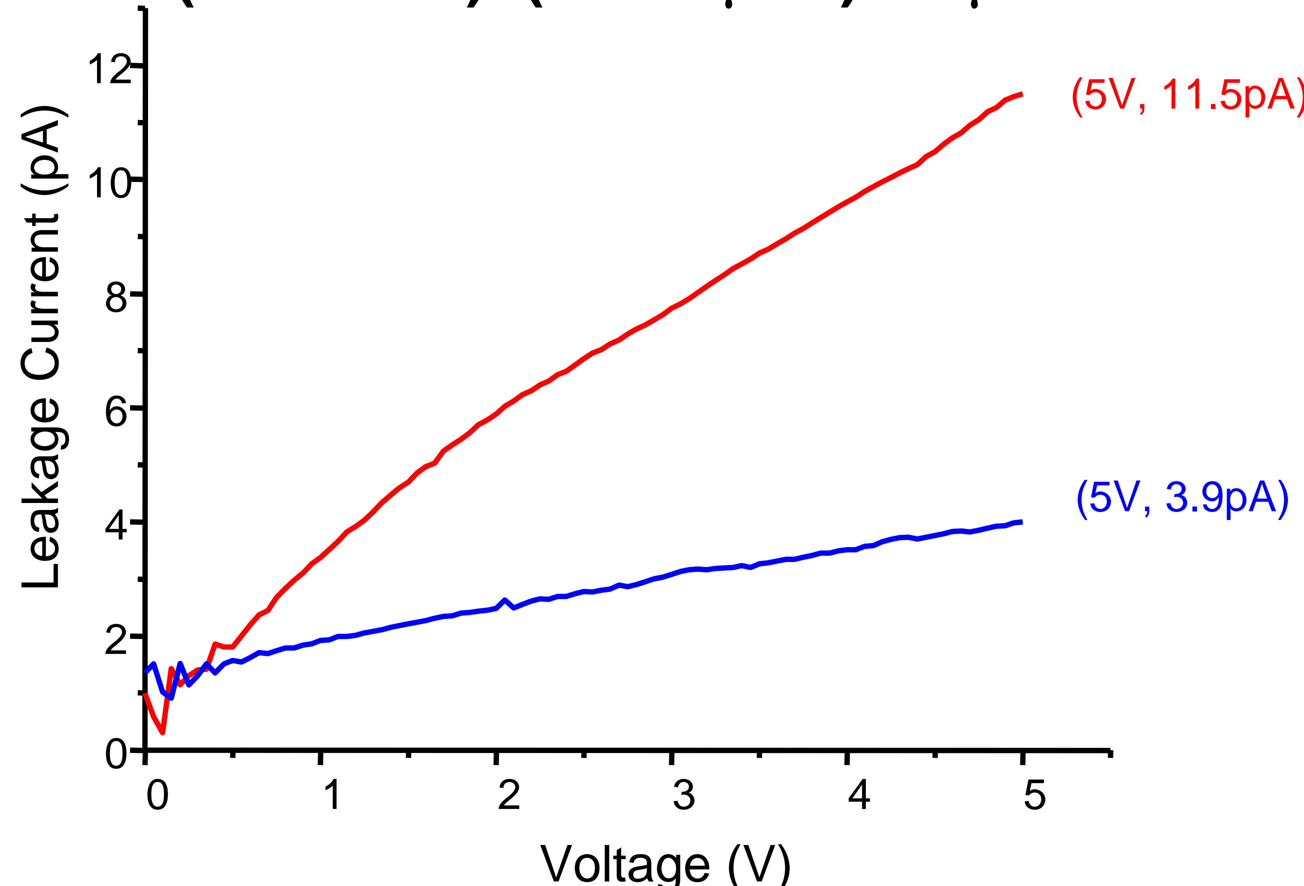
Protocol

1.	XeF_2	50 x 50 μm	to expose Al power plane,
2.	Ins Dep	49 x 49 μm	~0.5 μm thick
3.	Ins Dep	52 x 52 μm	~1.0 μm thick
4.	XeF_2	1.5 x 1.5 μm	to expose Al trace
5.	Moly Dep	1.4 x 1.4 μm	for via to Al trace
6.	Moly Dep	50 x 50 μm	to form contact pad
7.	Moly Dep	50 x 2 μm	to connect contact pad to via



Results

- Vertical leakage current
- Leakage current between two pins (on same chip) NOT connected by an insulator deposition structure
- **$R = 5V/(11.5 - 3.9) \times (50 \times 50 \mu m^2)/1.5 \mu m = 1.1 \times 10^{16} \mu\Omega\text{-cm}$**



Summary

- Single component Precursor
- High resistivity > 10^{16} μΩ-cm
- Yield = 1 to 3.5 $\mu m^3/nC$
- Rate = ~60 nm/min