notice that remaining SiO₂ is undercut from the sides of the Device Layer anchors

2. Thin Film Metallization (such as sputtering)
→ thinner than the Box Layer thickness

observe that remaining Box Layer prevents shorting between Device Layer islands and the handle layer

4. SIMOX SOI wafers

Oxygen ions accelerated and impact Si wafer (Ion Implantation) →
→ move into the Si wafer to a specific depth → form an SiO₂ layer

→ Device layer is thin ~200nm for example, Box ~375nm
→ These SOI wafers used in special IC fabrication processes

SIMOX → Separation-by-Implantation-of-Oxygen
Chapter 11 - Surface Micromachining

- using the Si substrate as a holder, where freestanding micromechanical structures are fabricated on the substrate surface through the addition (deposition) and subtraction (etching) of thin films, using sacrificial layers

a. Deposited thin and thick films
   1. Thick films \( \Rightarrow \geq \text{few } \mu \text{m} \) thick
   2. Thin films \( \Rightarrow \leq \text{few } \mu \text{m} \) thick

b. Thick film deposition
   1. Screen printing
   2. Plating \( \Rightarrow \) electro and electroless
   3. Spin coating
   4. Lamination \( \Rightarrow \) layers bonded through pressure and heat

c. Thin film deposition (more typical of Surface Micromachining)
   1. Sputtering

![Diagram of sputtering process]

\( \text{Ar}^+ \) ions bombard sputtering target with sufficient KE to knock target material atoms off. They diffuse across the vacuum chamber and strike
the wafer at ~90°, building up a thin film
→ metals and dielectric materials can be sputtered

3. Evaporation

The material to be deposited is evaporated in a vacuum chamber. The vapor diffuses across the vacuum chamber and deposits on the Si wafer at ~90°

- "thermal evaporation" → uses resistive heating to vaporize the deposition material
- Electron Beam or "E-Beam" Evaporation
  - uses an electron beam to evaporate the target material in the crucible
  - 2 electron beam system → evaporate 2 materials at the same time to deposit compound materials
  - system typically has several crucibles for depositing more than one material without breaking vacuum

ex: Au - top layer → wire bondable, prevents Ni oxidation
   Ni - barrier layer → prevents Ti/Au diffusion
   Ti - adhesion layer → bonds top layers to Si/SiO₂
Chemical Vapor Deposition (CVD)

- Solid thin films deposited on a wafer by vapor condensation or by adhesion of solid-phase reaction byproducts
- Reaction energy provided by heat or plasma power

Low-Pressure Chemical Vapor Deposition (LPCVD)

- Heat energy at low pressure (~ few hundred mTorr) $E_{\text{770 Torr}} = 1$ atm, $3$ kPa
- 580° to 620°С + Silane gas ($SiH_4$) $\Rightarrow$ polysilicon deposition
- Below 580° $SiH_4$ $\Rightarrow$ amorphous Si deposition
- 800°С + $SiH_4$ or dichlorosilane $SiCl_2H_2$ + ammonia ($NH_3$) $\Rightarrow$ Silicon Nitride ($Si_3N_4$) or $Si_xN_y$ can occur
- 500°С + $SiH_4$ + $O_2$ $\rightarrow$ $SiO_2$ $\&$ undoped $\Rightarrow$ called Low Temp Oxide (LTO)$^5$
  - If phosphorous doped with phosphine ($PH_3$) the glass is called phosphosilicate glass (PSG)
    - Etches faster in HF than LTO
    - Etch rate $> \mu$m/min