Semiconductor Technology from A to Z

Micromechanics

Sacrificial Layer Technique

The Principle of the Sacrificial Layer

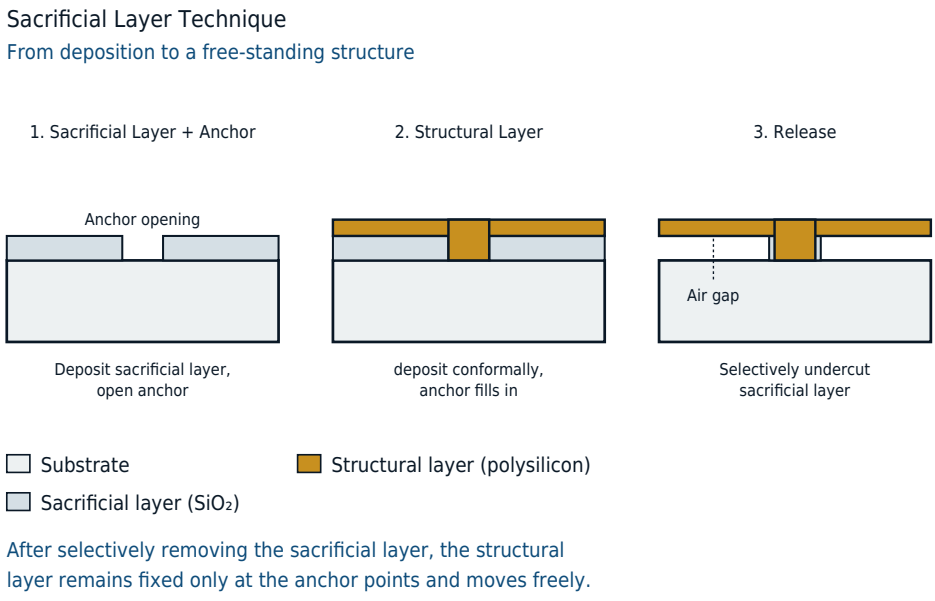
To create a free-standing structure – such as a cantilever beam or a membrane – it cannot simply be deposited directly on the substrate: it would remain permanently bonded to the underlying material and be unable to move. The sacrificial layer technique solves this by first depositing a temporary intermediate layer (the sacrificial layer) on the substrate. The actual functional layer (the structural layer) is then deposited and patterned on top of this sacrificial layer. At the end of the process, the sacrificial layer is selectively etched away – it is "sacrificed" so that the structural layer is left free-standing.

A classic material pair is silicon dioxide as the sacrificial layer and polysilicon as the structural layer: both can be deposited with established CVD processes, and hydrofluoric acid (HF) etches SiO_2 very selectively without significantly attacking the polysilicon.

Process Flow: Deposit, Pattern, Release

The process typically follows four steps. First, the sacrificial layer is deposited over the entire surface and opened with a lithography and etch mask wherever the structural layer will later be anchored to the substrate (the future "anchors" of the structure). The structural layer is then deposited over the entire surface – it fills the anchor openings and otherwise lies flat on the sacrificial layer. A further lithography and etch step shapes the structural layer into its final form, such as the beams or comb fingers of a sensor.

In the final step, known as release, the sacrificial layer is selectively undercut: the etchant advances laterally beneath the structural layer, dissolving it everywhere it is not attached to an anchor. What remains is a free-moving structure, fixed only at the anchor points.



Stiction: Sticking of Released Structures

A practical problem during the release step is stiction (from "static friction"): after wet-etching the sacrificial layer, the structure must be dried, and the surface tension of the evaporating liquid can pull the thin, compliant structural layer down onto the underlying substrate – where it remains permanently stuck by van der Waals forces and capillary forces instead of moving freely.

Common countermeasures include supercritical CO_2 drying (which avoids the liquid-gas interface transition entirely), dedicated spacers (dimples) on the underside of the structural layer that minimize contact with the surface below, and hydrophobic coatings that reduce adhesion.