1 Oxidation

1.1 LOCOS process

1.1.1 Very large-scale integration

In microfabrication structures are created with photolithography and etch processes. Thus steps are generated on which photoresist can accumulate and reduce the resolving capacity. Due to isotropic etch processes, the resist masks have to be adjusted to ensure the correct size of transfered structures.

At those steps also difficulties during metallization can occur, since conductors are narrowed, and therefore damage due to electromigration is the consequence.

To realize high packing density, in other words to create many devices next to each other in an area as small as possible, steps and other uneven surfaces have to be avoided. This can be done with the LOCOS process: short for LOCal Oxidation of Silicon.

1.1.2 Bird's beak

The LOCOS process utilizes the different rates of oxidation of silicon and silicon nitride, which is used for local masking.

The silicon nitride masks regions where no oxidation should occur, the oxide only growths on the bare silicon. Since silicon and silicon nitride have different coefficients of thermal expansion, a thin oxide layer - the pad oxide - is deposited between the silicon and the silicon nitride to prevent strain due to temperature changes.

For lateral isolation of transistors, a so-called field oxide (FOX) is deposited on the bare silicon surface. While the oxidation on the bare silicon takes place, the pad oxide causes a lateral diffusion of oxide beneath the silicon nitride and thus a slight growth

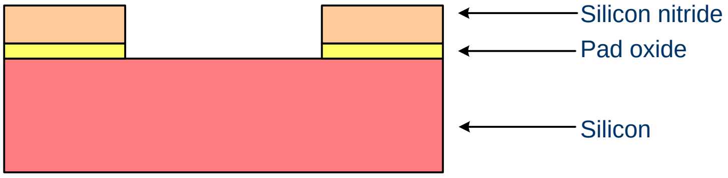
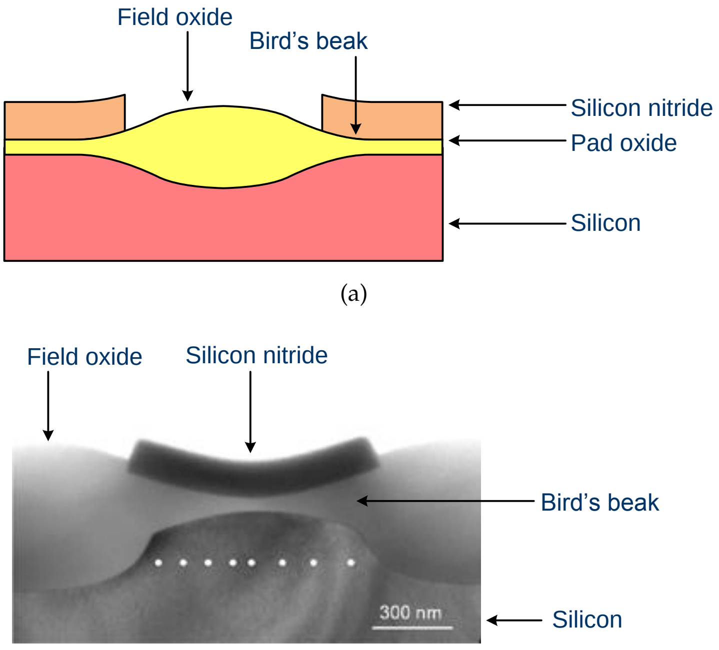


Fig. 1.1: Basic film layer stack

of oxide at the edge of the nitride mask. This extension has the shape of a bird's beak whose length depends on the length of the oxidation process and the thickness of the pad oxide and the nitride as well.



(a)

(b)

Fig. 1.2: LOCOS profile after oxidation

Beside this effect, the white ribbon or kooi effect can occur during wet oxidation processes. Thereby nitride of the masking and hydrogen used for the wet oxidation react to form ammonia NH3 which can diffuse to the silicon surface and cause a nitridation. This nitride has to be removed before the gate oxide is deposited because it acts as a masking and prevents oxide growth.

Despite this negative effects, the LOCOS process is an appropriate method to facilitate very large-scale integration. In addition, due to the better uniformity without steps and edges as occur on etched structures, the resolving capacity is improved. The field oxide can be etched back slightly, thus the deposited oxide is removed a bit but the length of the bird's beak is decreased and therefore the surface is even more flattened. This is called fully recessed LOCOS.

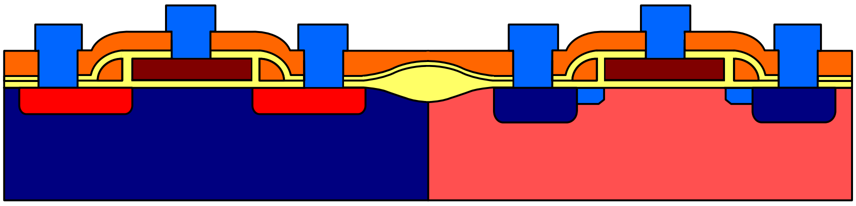


Fig. 1.3: Example of the LOCOS process for lateral isolation of transistors

1.1.3 Alternative

Instead of the local oxidation in modern processes trenches are etched into the silicon substrate and filled with an oxide film to insulate adjacent devices. This so called shallow trench isolation (STI) requires much less space than the locos process, however, more process steps have to be done. Since the trenches are used to isolate transistors the STI process is one of the first process in wafer fabrication. Besides the shallow trench isolation there is a deep trench isolation which is mainly used for anlog devices.

In the 45 nm technology node the trenches for STI are about 100 nm (SOI) or 300 nm (bulk) respectively.