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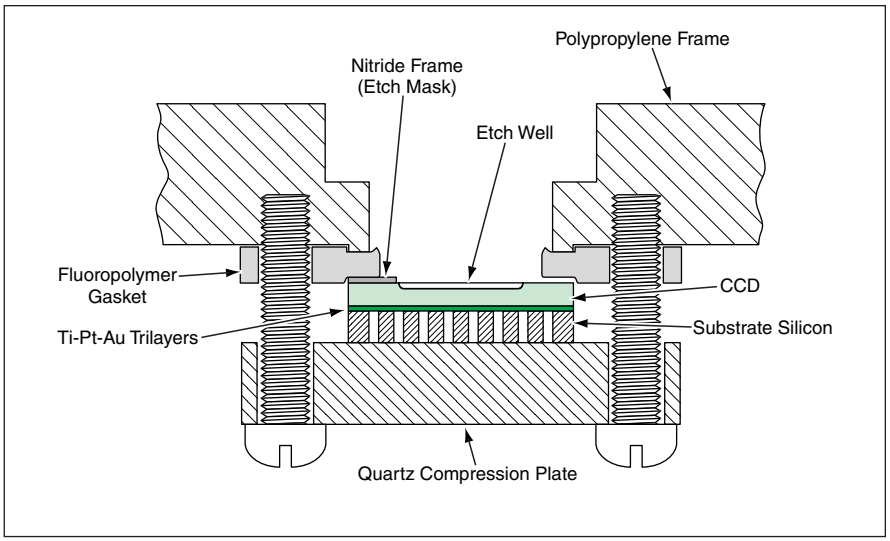
Chemical Thinning Process for Fabricating UV-Imaging CCDs

This process can be used in making CCDs that exhibit high quantum efficiencies.

NASA's Jet Propulsion Laboratory, Pasadena, California

The thinning stage of the postfabrication process reported in the immediately preceding article is notable in its own right. Although the thinning process was described in the preceding article as part of an overall process of fabrication of a supported charge-coupled device (CCD), it is more generally applicable to both free-standing and supported devices that have been fabricated in die and wafer formats. Like the thermocompression bonding process described in the preceding article, the thinning process is compatible with CCD-fabrication processes, as well as postfabrication processes that enhance the response of CCDs to ultraviolet (UV) light, including the delta-doping process. CCDs that are thinned by this process and then delta-doped exhibit high quantum efficiencies that are stable with time and with exposure to the environment.

Once the CCD and substrate have been joined by the thermocompression bonding, the CCD/substrate unit is placed in a fixture with the back side of the CCD die or wafer (the side to be etched) facing up, as shown in the figure. KOH has been chosen as the etchant because it preserves the mirror-smooth finish previously imparted to the CCD wafer or die back surface by chemical mechanical polishing. During etching, a quartz refluxer is used to maintain the concentration of KOH at 55 percent by weight and the solution is stirred continuously and maintained at a temperature of ≈80 °C. The etch rate is between 0.5 and 1.0 μm/min, the exact rate depending on the exact temperature of the solution. Gaskets, along with other parts of the fixture not shown in the figure, seal the die or wafer in the fixture to protect the front-side CCD circuitry against exposure to KOH.



A **CCD Bonded to a Silicon Substrate** via trilayers of Ti, Pt, and Au is held in a fixture with its back side up for chemical etching to reduce its thickness.

At several intervals during the KOH etch, the fixture is removed from the KOH solution, rinsed, and dried in order to measure the depth of the etch. The etching times are calculated to bring the depth of the etched well to within 20 μm of the epilayer of the CCD device. Removal of the last 20 μm of silicon leading to the epilayer is made by use of a mixture of hydrofluoric, nitric, and acetic acids, which is highly selective: this mixture etches the p^+ bulk silicon at a rate of ≈1.5 μm/min, and the etch rate falls nearly two orders of magnitude once the p^- epilayer is encountered. Hence, the mixture can be used to remove the remaining p^+ layer. This etch is closely monitored for arrival at the epilayer as indicated by a change in the color, pattern, and intensity of the activity at the solid/liquid interface. Once this etch has been completed, there is a 60-second exposure to another mixture comprising different proportions of the three acids to remove a characteristic dark haze left by etching with the first mixture of the acids. The final etching step is a 90-second exposure to $KMnO_4$ hydrofluoric acid solution to remove a faint white haze left by the second acid mixture.

This work was done by Todd Jones, Paula Grunthaner, Shouleh Nikzad, and Rick Wilson of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*

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JPL
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