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(54) MITIGATING SURFACE DAMAGE OF PROBE PADS IN PREPARATION FOR DIRECT BONDING OF A SUBSTRATE

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(57) **ABSTRACT**

Mitigating surface damage of probe pads in preparation for direct bonding of a substrate is provided. Methods and layer structures prepare a semiconductor substrate for direct bonding processes by restoring a flat direct-bonding surface after disruption of probe pad surfaces during test probing. An example method fills a sequence of metals and oxides over the disrupted probe pad surfaces and builds out a dielectric surface and interconnects for hybrid bonding. The interconnects may be connected to the probe pads, and/or to other electrical contacts of the substrate. A layer structure is described for increasing the yield and reliability of the resulting direct bonding process. Another example process builds the probe pads on a next-to-last metallization layer and then applies a direct bonding dielectric layer and damascene process without increasing the count of mask layers. Another example process and related layer structure recesses the probe pads to a lower metallization layer and allows recess cavities over the probe pads.