Mechanical Response Investigation of Wafer Probing Test with Vertical Cobra Probe via the Experiment and Transient Dynamic Simulation

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Abstract : Wafer probing tests play an important role in semiconductor manufacturing procedures in accordance with the yield and reliability requirement of the wafer after the backend-of-the-line process. Accordingly, the stable physical and electrical contact between the probe and the tested wafer during wafer probing is regarded as an essential issue in identifying the known good die. The probe card can be integrated with multiple probe needles, which are classified as vertical, cantilever and micro-electro-mechanical systems type probe selections. Among all potential probe types, the vertical probe has several advantages as compared with other probe types, including maintainability, high probe density and feasibility for high-speed wafer testing. In the present study, the mechanical response of the wafer probing test with the vertical cobra probe on 720 μm thick silicon (Si) substrate with a 1.4 μm thick aluminum (Al) pad is investigated by the experiment and transient dynamic simulation approach. Because the deformation mechanism of the vertical cobra probe is determined by both bending and buckling mechanisms, the stable correlation between contact forces and overdrive (OD) length must be carefully verified. Moreover, the decent OD length with corresponding contact force contributed to piercing the native oxide layer of the Al pad and preventing the probing test-induced damage on the interconnect system. Accordingly, the scratch depth of the Al pad under various OD lengths is estimated by the atomic force microscope (AFM) and simulation work. In the wafer probing test configuration, the contact phenomenon between the probe needle and the tested object introduced large deformation and twisting of mesh gridding, causing the subsequent numerical divergence issue. For this reason, the arbitrary Lagrangian-Eulerian method is utilized in the present simulation work to conquer the aforementioned issue. The analytic results revealed a slight difference when the OD is considered as 40 μm, and the simulated is almost identical to the measured scratch depths of the Al pad under higher OD lengths up to 70 μm. This phenomenon can be attributed to the unstable contact of the probe at low OD length with the scratch depth below 30% of Al pad thickness, and the contact status will be being stable when the scratch depth over 30% of pad thickness. The splash of the Al pad is observed by the AFM, and the splashed Al debris accumulates on a specific side; this phenomenon is successfully simulated in the transient dynamic simulation. Thus, the preferred testing OD lengths are found as 45 μm to 70 μm, and the corresponding scratch depths on the Al pad are represented as 31.4% and 47.1% of Al pad thickness, respectively. The investigation approach demonstrated in this study contributed to analyzing the mechanical response of wafer probing test configuration under large strain conditions and assessed the geometric designs and material selections of probe needles to meet the requirement of high resolution and high-speed wafer-level probing test for thinned wafer application.

Keywords : wafer probing test, vertical probe, probe mark, mechanical response, FEA simulation
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