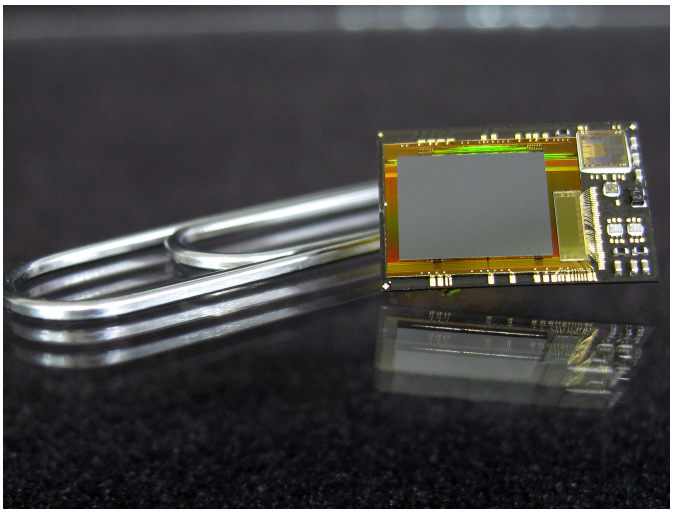
CASE STUDY

Secure Micro SD Card

Develop the materials and assembly process to manufacture a secure Micro SD Card for government and financial services applications.

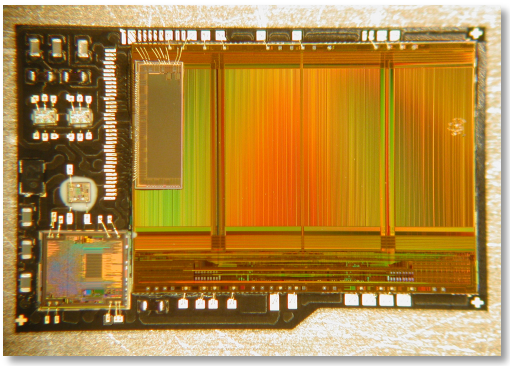


BACKGROUND: MicroSD cards are ubiquitous as a removable storage medium. In their standard configuration, and as a stand-alone memory device, they are not secure and usually the electronic devices they are used in do not incorporate secure hardware. There are applications in the financial and government markets where embedding a secure microprocessor into the card enables it's use in otherwise unsecure portable electronic devices.

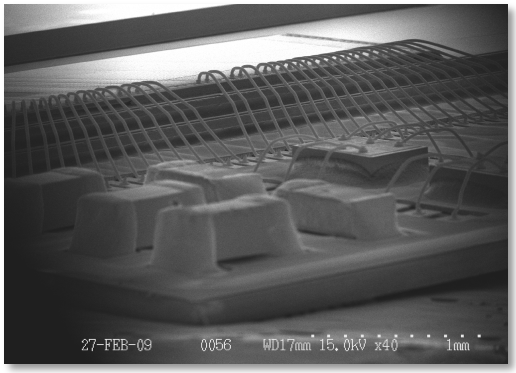
PROJECT DETAILS: MicroSD cards have been the technology driver for advanced wafer thinning and 3D die stacking technologies since their inception, but since MicroSD cards are manufactured almost exclusively in Asia, there is little technology or capability within North America for manufacturing them. The customer needed to establish a domestic source for building custom secure MicroSD cards and was willing to use standard die components to do so. The customer desired to remain anonymous so all component procurement was coordinated with the supply base on their behalf. The customer retained all electrical design responsibility, while physical design responsibility, including die and card assembly, substrates, material and passive component selection was handled by Aspen.

The project required that several major technologies be developed. These included: thinning of standard 200mm and 300mm silicon wafers down to 50 microns, die stacking on thin organic substrates using dicing die attach films (DDF), integration of SMT processes with the die assembly, ultra-low loop wirebonding, and transfer molding of the mixed technology assembly into the MicroSD form factor, and finally a laser de-paneling process to create the final MicroSD form factor.

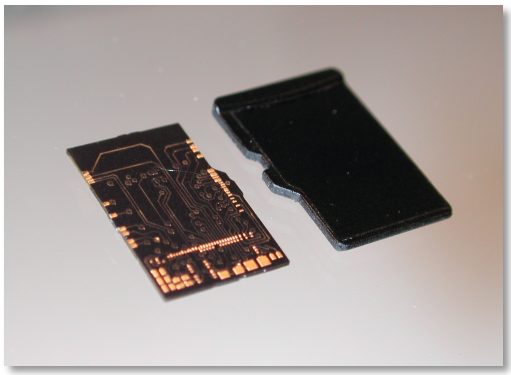
The thinning fabricated 300mm wafers to 50 microns thick involved a set of backgrind and polish operations that was developed at a domestic subcon. At the time, DDF materials were relatively new and not generally available in the US, so provisions needed to be made to import these materials. A DDF lamination and dicing process was developed in house to provide rapid cycle time in understanding the interactions between these materials and the ultra-low loop wirebond processes they had to be compatible with. Custom tooling and fixturing had to be developed, not only to handle and place the very thin die



The assembled MicroSD card prior to molding



SEM photo of the wirebonds from the memory controller to the substrate



A MicroSD substrate prior to assembly and a completed MicroSD card

which had a backside DDF layer, but also to allow the cards to be built in a panel form that was compatible with the rest of the assembly process. The highest density cards required that four identical flash memory chips be stacked directly on top of each other with wirebonds emerging from the DDF and terminating on the thin organic substrate. A controller chip was placed on top of the four die stack and wirebonded. The entire 5 die stack, including substrate and overmolding had to be within the MicroSD thickness form factor of 0.5mm

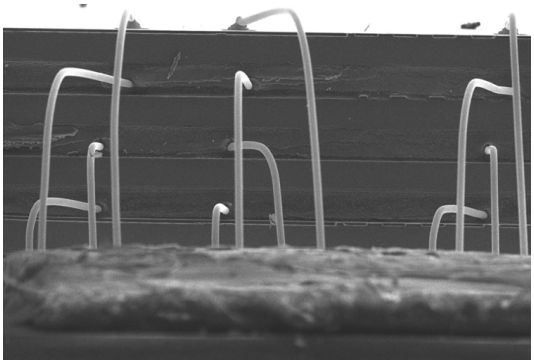
Passive SMT components (0201 and 0402) were soldered to the panel prior to die attach and wirebond. A secure microprocessor was procured in wafer form, background, diced and placed on the panel along with a power control chip and the appropriate flash memory controller.

Panels of MicroSD cards were then transfer-molded using the Boschman "film-assisted molding" process to ensure the assembly was fully encapsulated, not voids were created and external electrical contacts were exposed in the completed device. Due to the complex and 3D nature of the assembly, stresses due to the molding process lead to failures in the early prototypes.

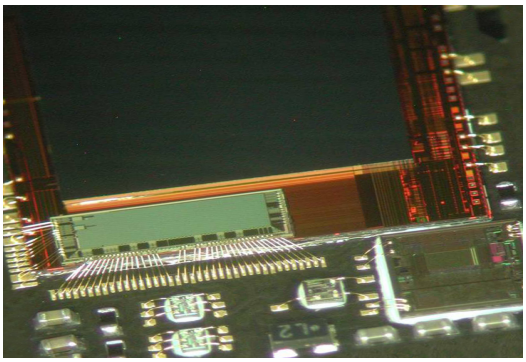
A combination of electrical testing, x-ray imaging and cross sectional analysis identified the location of the die fractures and changes in the mold compound, and molding process were implemented to eliminate the issue.

As a last step in the fabrication process, a laser cutting operation was developed to de-panelize the parts from the array and to create the MicroSD standard form factor. Completed devices were functionally tested and samples of material were subjected to industry standard reliability tests to qualify the devices.

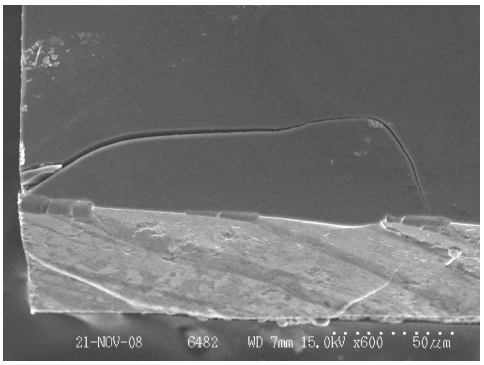
Upon qualification, the MicroSD cards were manufactured according to the established security protocols and quality documentation. After the initial MicroSD card was manufactured, additional versions of the card were made to satisfy a number of different application requirements.



SEM photo showing the die stack with wirebonds emerging from the DDF



A close up of the SMT portion of a MicroSD card



A crack in a die after transfer molding.

RESULT: 16G MicroSD cards with embedded secure microprocessors and other interface circuits were successfully developed and manufactured. The cards met all performance and reliability objectives and were fully compliant with the MicroSD standard in form and function. The technologies associated with wafer thinning, die stacking, low-loop wirebonding and transfer molding were each developed and qualified for production. The development phase for the first generation product lasted 14 months and subsequent versions of the memory cards were developed in cycles that typically lasted less than 6 months. Sufficient quantities of the memory cards were manufactured in a one-time build/buy scenario to provide the necessary inventory to meet the customer's needs for the life of the program.