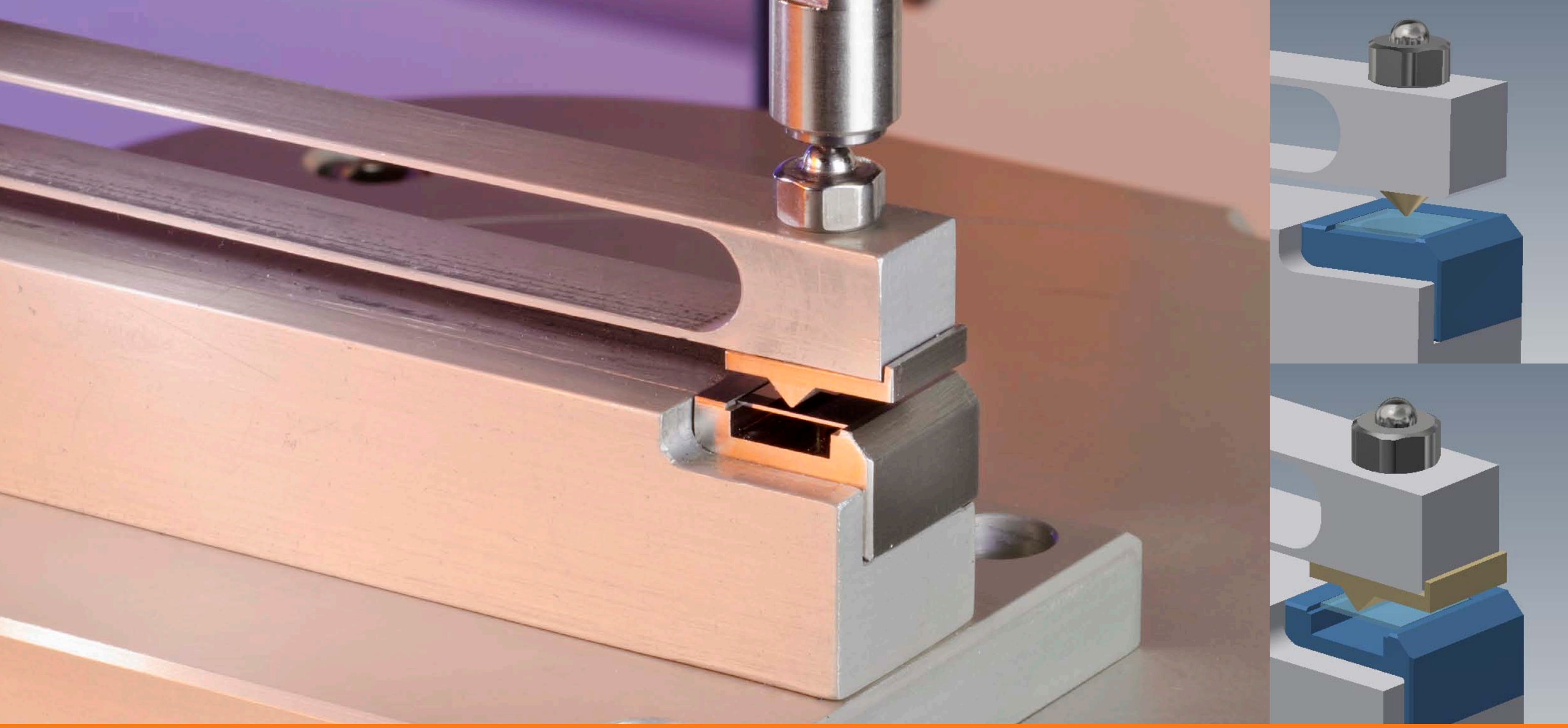


Brittle Fracture – Micro Bend

Application Note

THE CHALLENGE

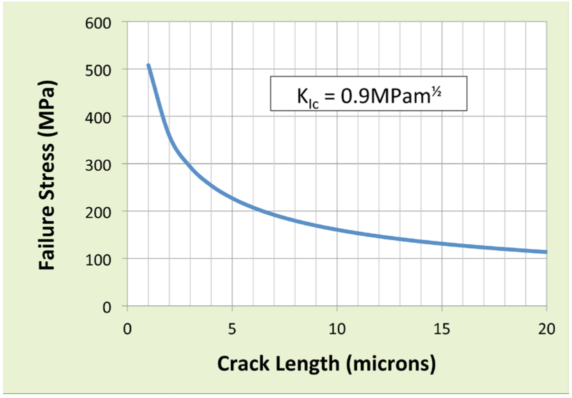
The strength of brittle materials, such as silicon and glass, is highly dependent on the presence of surface defects such as scratches and chips. In these materials the high level of stress at the tip of a crack cannot be relieved by plastic flow and so even very small defects can lead to low failure loads.

For silicon dies, the dicing process can produce micro-cracks along the cut edge and back thinning can result in small surface cracks. Even in the absence of mechanical flexure, thermal expansion mismatch between the die and the substrate on which it is mounted will stress the die, with the possibility of failure of the device.

As dies get larger, the risk of failure increases and the ability to assess the impact of processing steps becomes more important.

THE SOLUTION

Our range of micro bend solutions are ideal for assessing the impact of defects introduced by dicing or surface grinding on the strength of brittle materials, such as silicon. The statistical nature of brittle fracture dictates that multiple samples are tested and this requires a method that is straightforward to use and repeatable.



Impact of crack length on failure stress for silicon

THE METHOD

Micro bend tooling used in conjunction with our 4000*Plus* micro materials test system provides the capability to repeatedly position small die and ensure the test load is correctly applied. A range of load cartridges enable these tests to be executed over a wide range of sample size and thickness. Compliance in the load cell ensures that the load rate is controlled even for small, stiff samples. Force-displacement data is automatically collected together with the peak failure force. The flexure used to support the tooling adds only a small additional force, which can be corrected, if required.

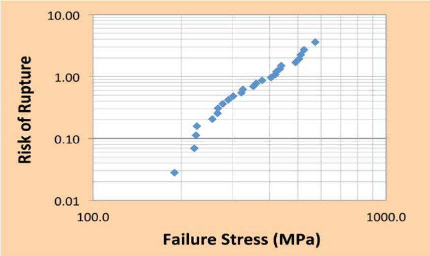
Different bend methods result in different stress distributions and methods used include; four point, three point, ring-on-ring and ball-on-ring (spherical bend). For three point bend a suitable test method is described in SEMI G86-0303.

Failure loads in four and three point bend are sensitive to both surface and edge cracks. The ring-on-ring and ball-on-ring methods do not stress the edges of the die. However, calculation of the surface stresses is more complicated and is generally done using finite element analysis.

THE RESULT

Brittle failure by its nature is statistical, with the failure load depending on the size, location and orientation of any defects present relative to the maximum principal stress. Multiple samples, typically more than 25 are tested to evaluate the distribution of failure loads.

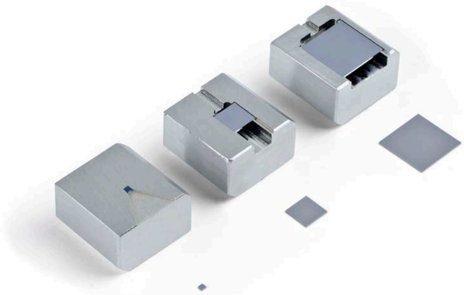
The Weibull strength distribution, that takes into account the effect of sample size, is perhaps the most appropriate way of analysing this data.



Weibull distribution of failure stress from 3pt micro bend measurements

Greater understanding requires us to be able to separate the effect of surface from edge defects. One way of doing this is to analyse data from tests that give different stress distributions. Further insight into the failure mechanism can be sought by sticking a plastic film to the compressive side so that the fragments are retained.

The bend test can be applied to other microelectronic components, such as SMT resistors and capacitors made from brittle glass or sintered ceramics. IEC 60068-2-77 includes a test procedure for measuring component body strength by subjecting the component to a form of three point bend test.



A series of precision machined work holders for performing bend measurements on samples from 1 – 10mm square

For more information, please contact your Nordson DAGE regional office or speak with your Nordson DAGE representative, all of which are listed on www.nordsondage.com.

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