Microstructure Fracture Prediction Service

Having trouble with **yield** or field losses?
Are **parts breaking** during processing?
Need to match **reliability** to customer requirements?
Upgrading an existing microstructure design?

A.M. Fitzgerald & Associates can help. We offer custom analysis services based on our proprietary fracture prediction algorithm.

Service Features

- Predict microstructure load limits before building final devices
- Find out where a structure is most likely to break and under what conditions
- Useful for MEMS, IC chips, optoelectronics, photovoltaics and other crystalline microstructures
- Keep IP secure – no need to reveal process details

Benefits

- Shorten design loop: predict structural limits before building final devices
- Improve yield by creating devices that are less likely to fail
- Increase confidence in performance specs
- Match device performance to market needs

Our microstructure failure and load limit prediction services are based on a patented* process:

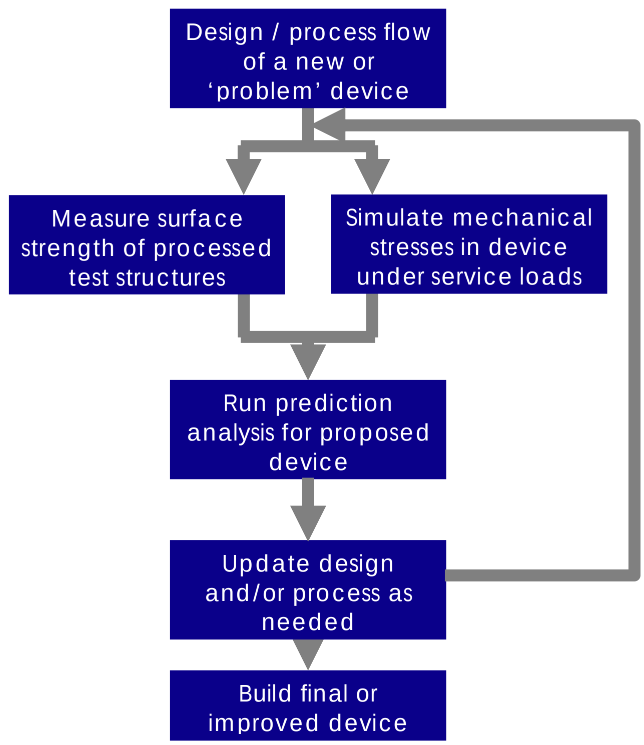
First, a statistical characterization of the influence of a manufacturing process on surface strength is obtained from test structures. This information is applicable to *any* device made by the same process.

Next, a finite-element model of a proposed or existing microstructure is created in ANSYS. Stresses in the microstructure device under an applied load are simulated. Many different load scenarios may be tested in the simulation.

Finally, the results of load simulation are combined with surface strength information to predict failure points and load limits. With this information, one may revise the device design or process, or proceed to manufacturing.

**US Patent #7,979,237*

Failure Prediction Flow Chart



How failure prediction works

Failures of crystalline microstructures occur at surfaces. The surfaces are weaker than the bulk crystalline material due to microscopic imperfections that are caused by manufacturing processes. Details such as tool type and operating parameters are very important.

The quality of etched surfaces, for example, depends strongly on etch process details. Different process parameters can lead to significant differences in surface strength and device fracture probability.

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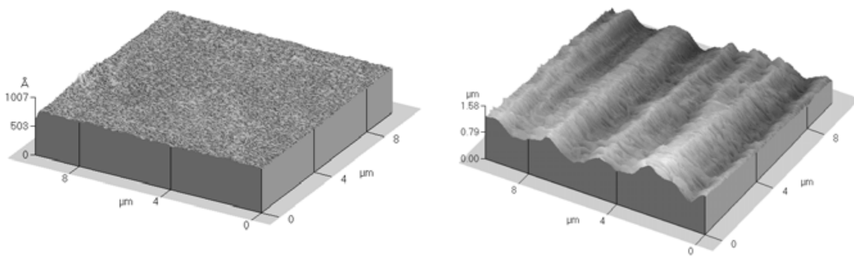
TMAH-etched silicon surface
R.M.S. Feature size = 24 Å

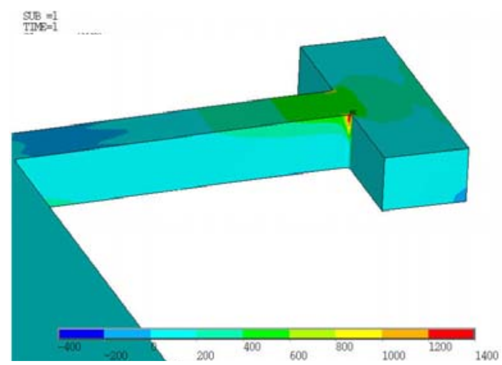
DRIE silicon surface
R.M.S. Feature size = 0.2 μm



Surface properties of silicon etched by different processes vary greatly and have a significant effect on fracture strength.

We quantify the effect that a manufacturing process has on surface strength using test structures. This yields information that is specific to a particular process run on a particular tool. However, our protocol is designed so that we never need to know our customers' proprietary process details.

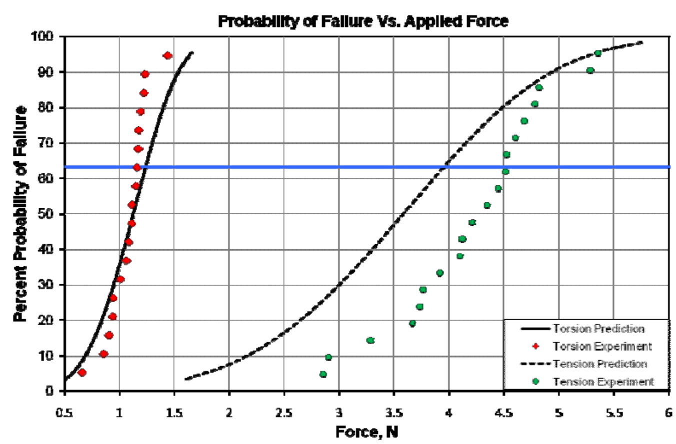
Relying on our deep experience with finite-element numerical simulation, we model stresses in devices under load. Load limits and failure points are then predicted by our algorithm, which combines simulation results with data on surface strength obtained from test structures.



Principal stress contours (MPa) in a silicon micro-mirror under tension, as modeled using finite element analysis

Further information and links to references are available online: www.amfitzgerald.com

Contact us at (650) 347-MEMS or info@amfitzgerald.com for an introductory consultation.



Sample output: Probability of failure versus applied force for a silicon micro-mirror. The prediction was verified by breaking actual micro-mirrors. The predicted characteristic strengths are within 7% and 12% of experimentally measured values for torsion and tensile loads, respectively.

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