

FLUID SHAPE APPLICATIONS FOR THE SILICON VALLEY

Solder Reflow & Hard Drive Media Processing



Fluid Dynamics

Structural Mechanics

Electromagnetics

Systems and Multiphysics

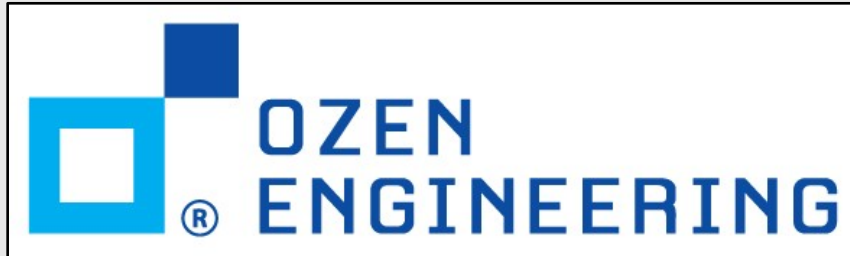
Chris Cowan, Ozen Engineering Inc.
Shaun Chen, Ph.D., Western Digital Corp.

ANSYS Convergence Conference
Santa Clara, CA
May 30, 2013



With over 25 years of experience in Finite Elements Simulations and Engineering Consulting, we collaborate with customers to provide the best in class expertise and solutions to their problems, enabling them to succeed.

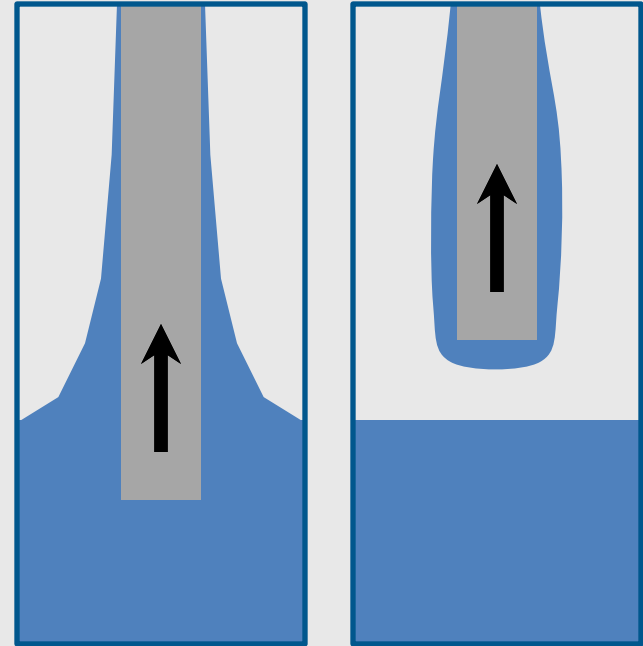
Introduction: Hard Drive Disk Coating



Manufacturing Process for Recording Media

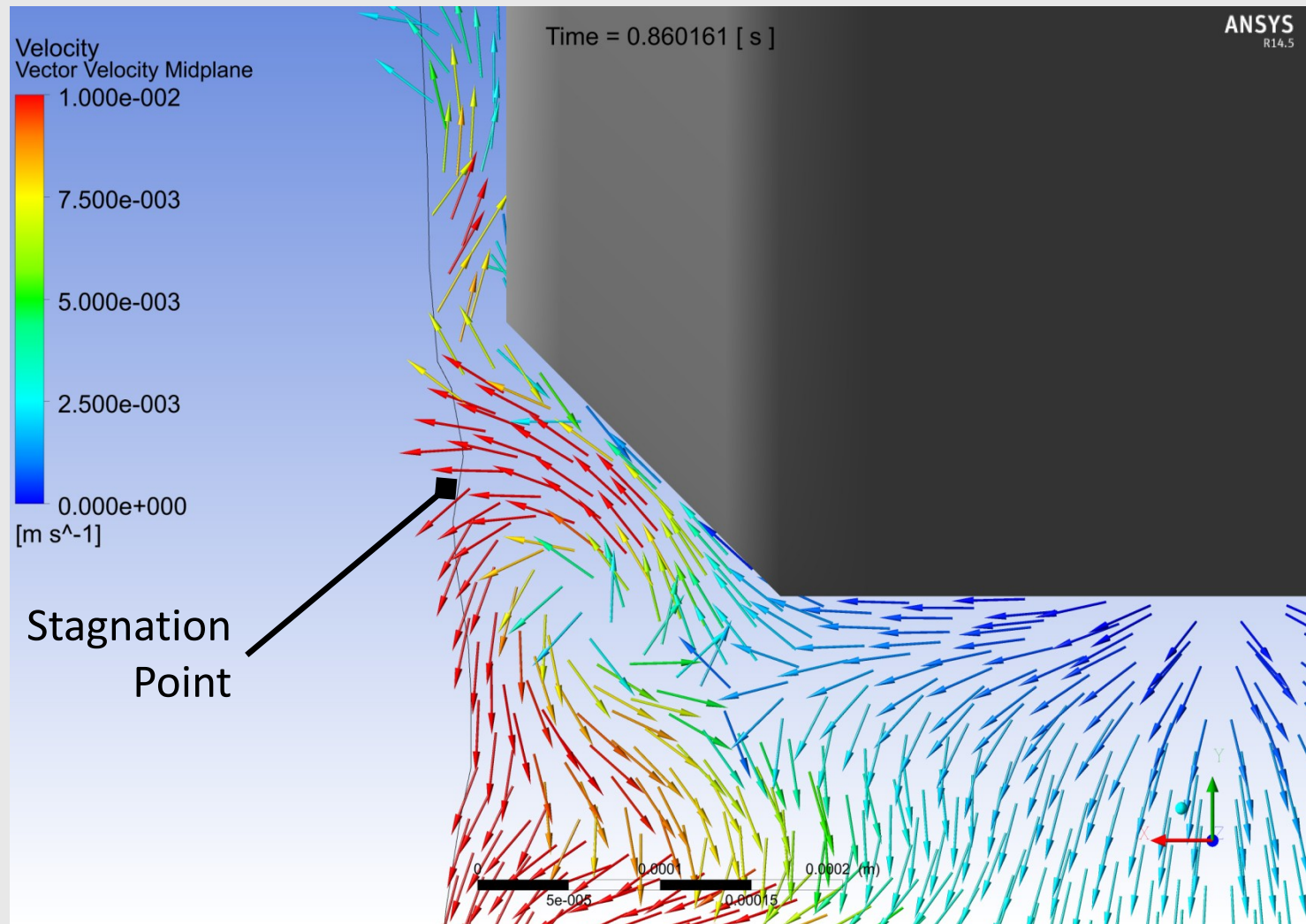
Lubricant film

Process conditions
determine thickness



Recording media in a fluid bath is
withdrawn & separated.

Dip Coating

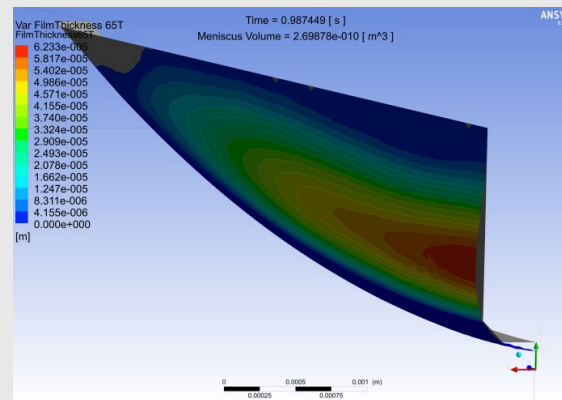
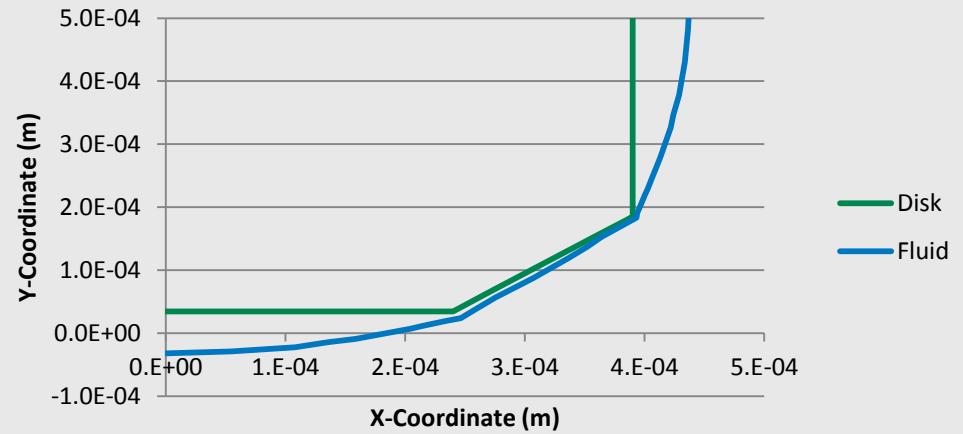


Non-uniform coating thickness

Droplet formation during separation from bath

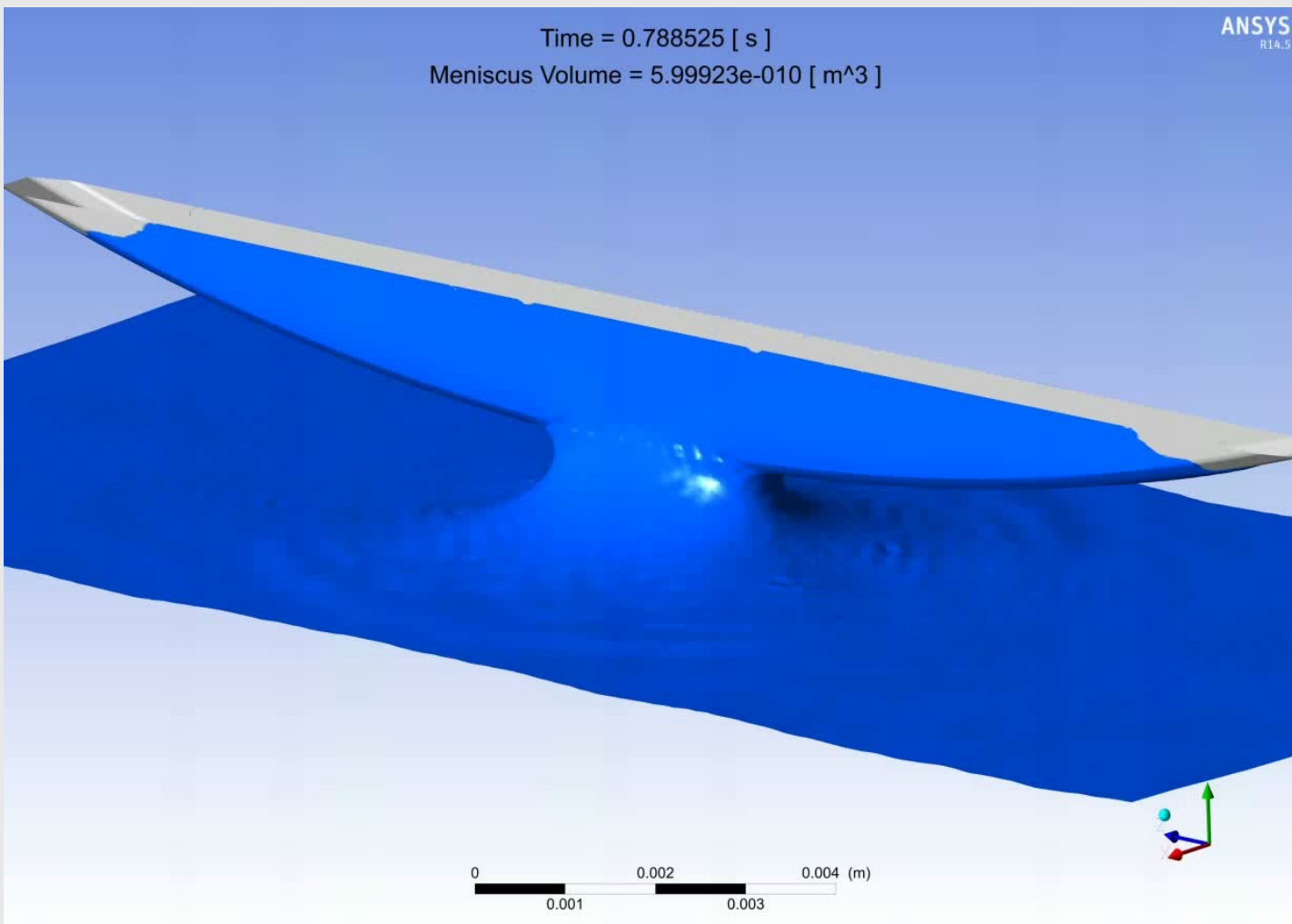
Reduce effect by tuning process equipment

Fluid Meniscus Cross-Section



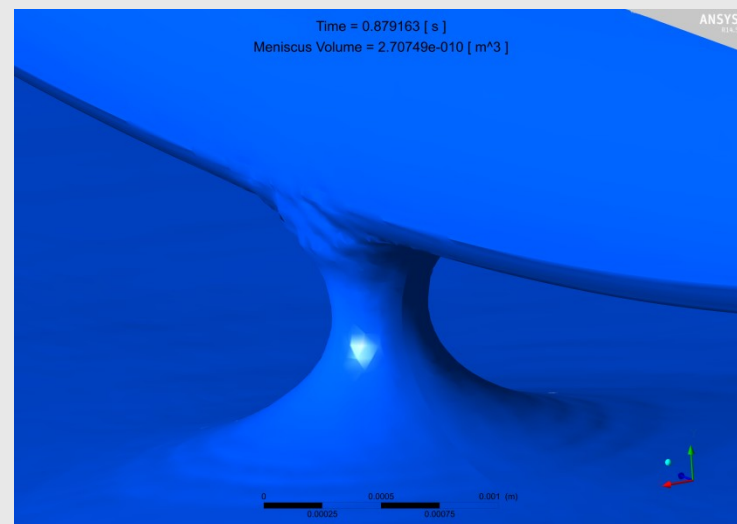
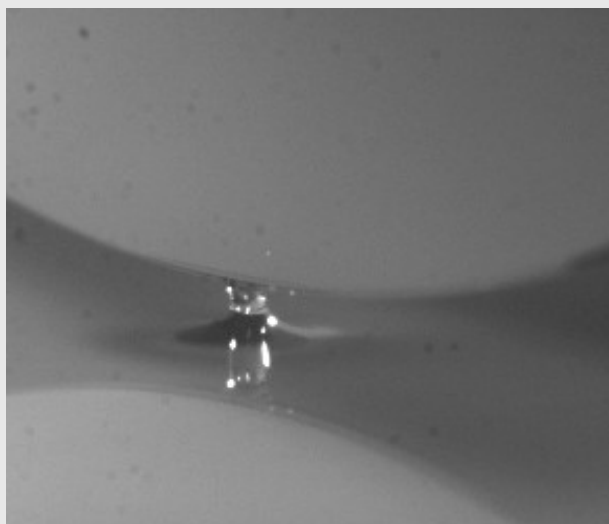
Dip coating equipment

Animation - Disk Withdrawal

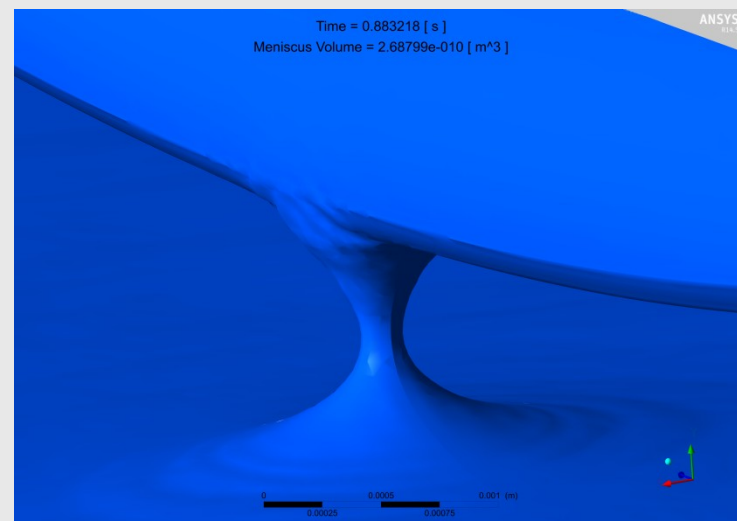
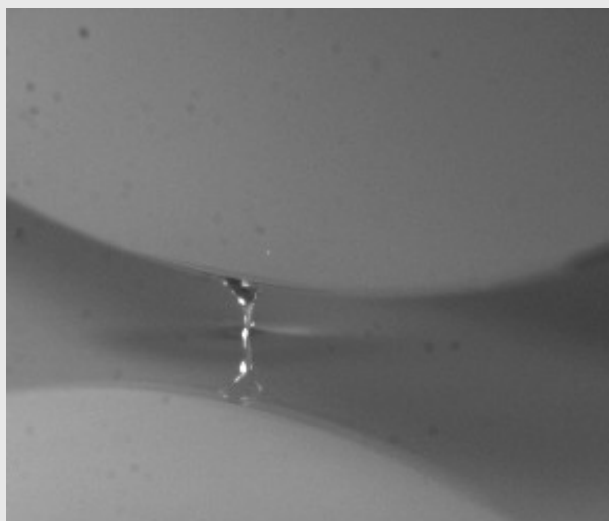


Experimental Comparison

Break Time – 6ms

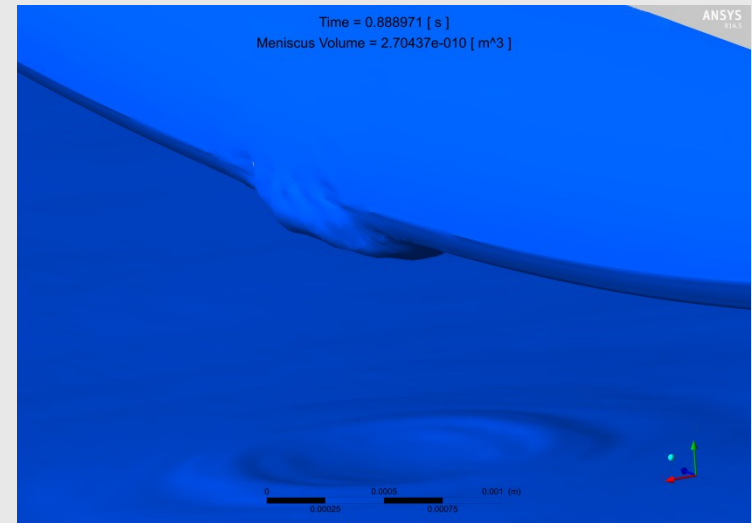
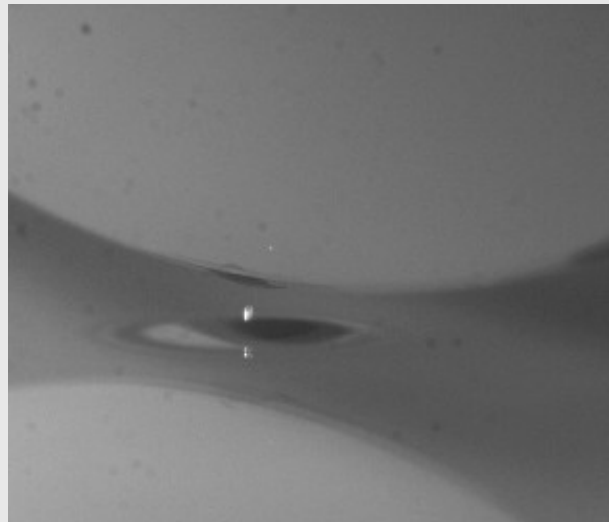


Break Time – 1ms

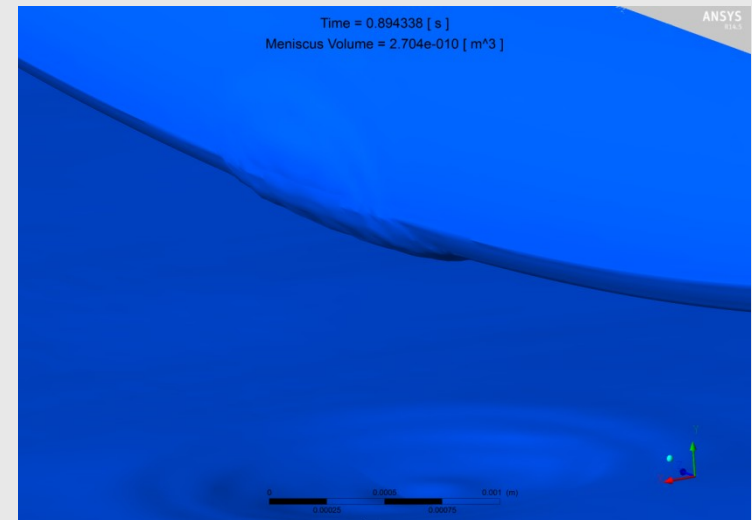
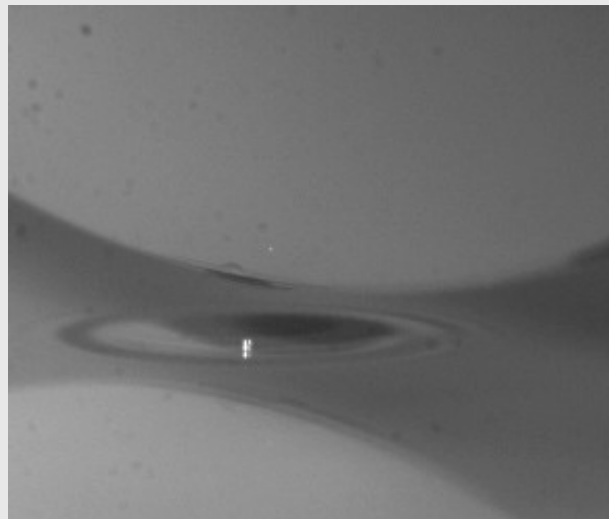


Experimental Comparison

Break Time + 4ms

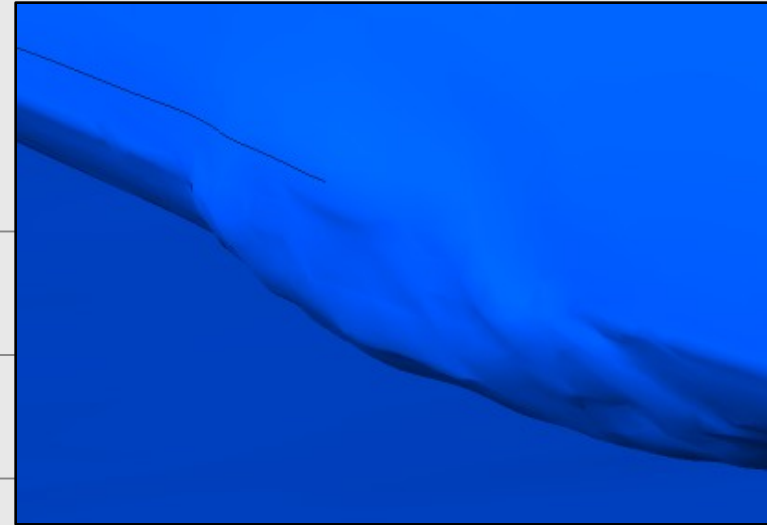
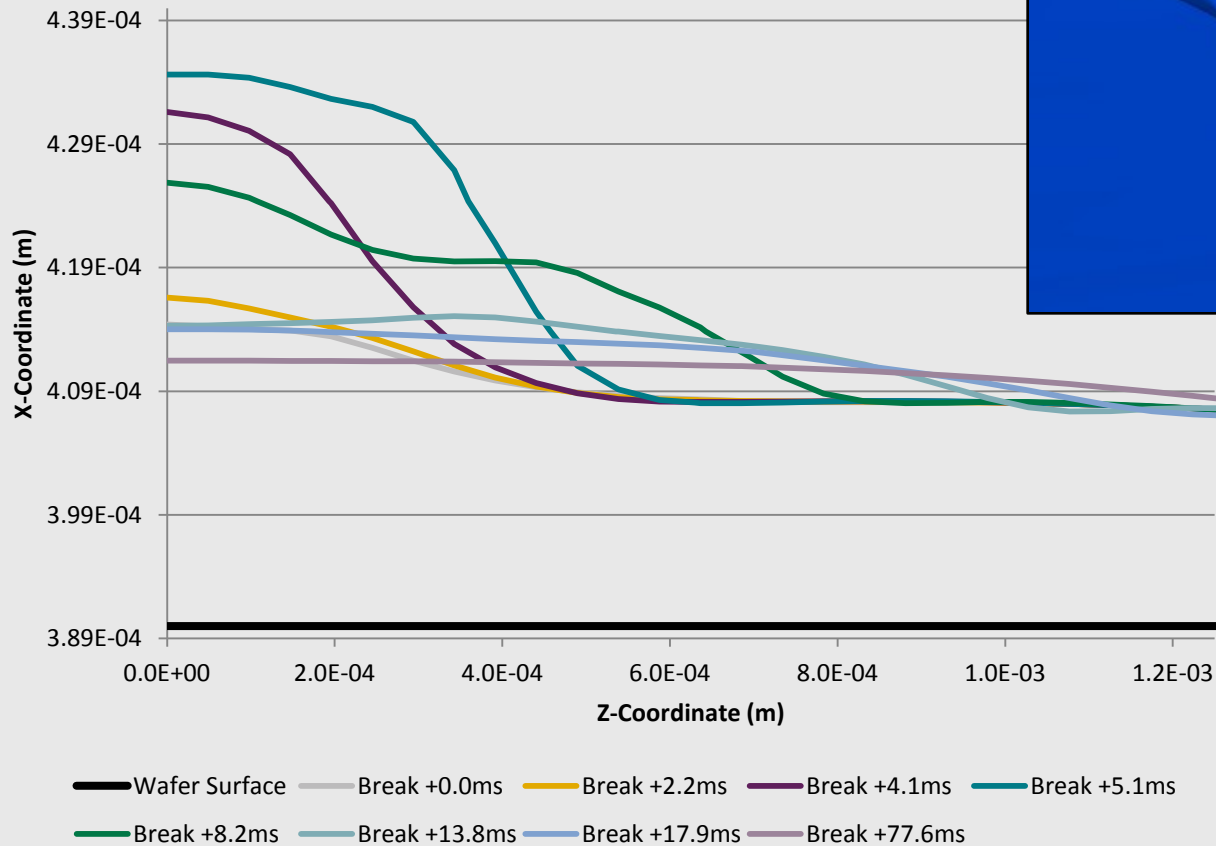


Break Time + 8ms



Transient Profile

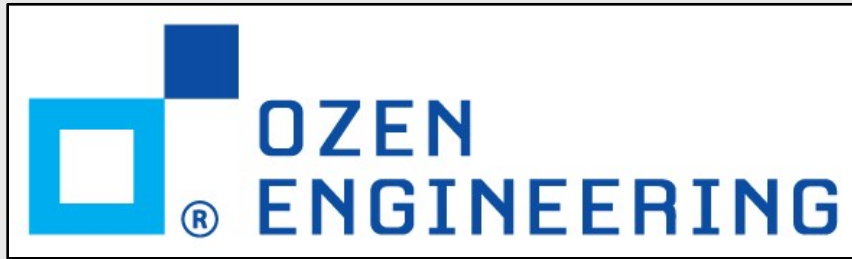
Fluid Meniscus at 0.25mm above Disk Bottom



Solution Challenges

- **Transient analysis, timesteps vs. end time**
- **Detailed free surface resolution**
 - **Thin film on wafer surface**
 - **Droplet formation**
- **Starting conditions**
 - **Viscosity, withdrawal**
- **Very slow processing velocity relative to VOF interface currents**

Introduction: Solder Reflow Shape Prediction



DFN 2x5



QFN 3x3
QFN 4x4



SO-8

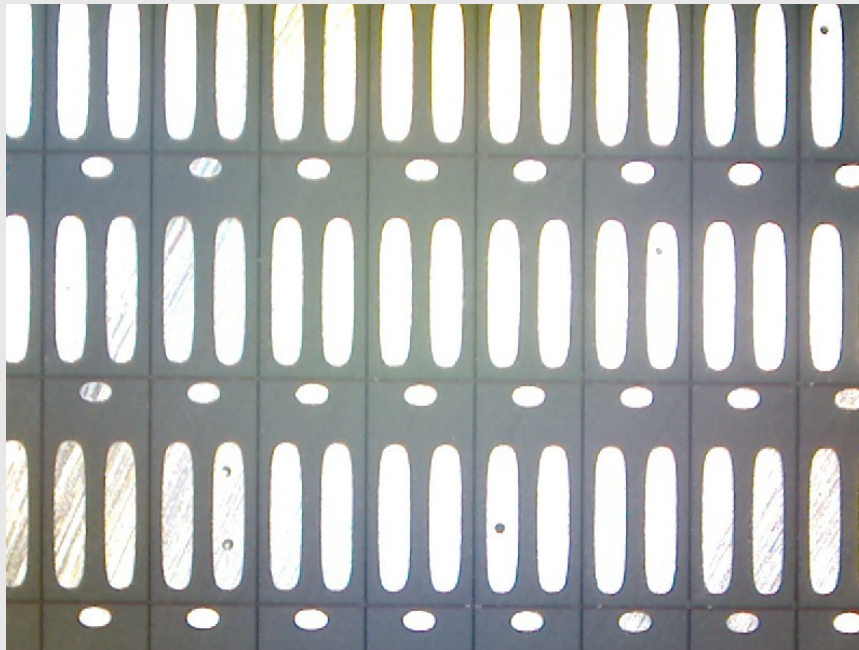


TO-220F

Project Description

Predict the shape of a reflowed solder joint

Minimize a process bottleneck resulting from removal of the top layer after encapsulation



Solder pads exposed following
encapsulant layer removal

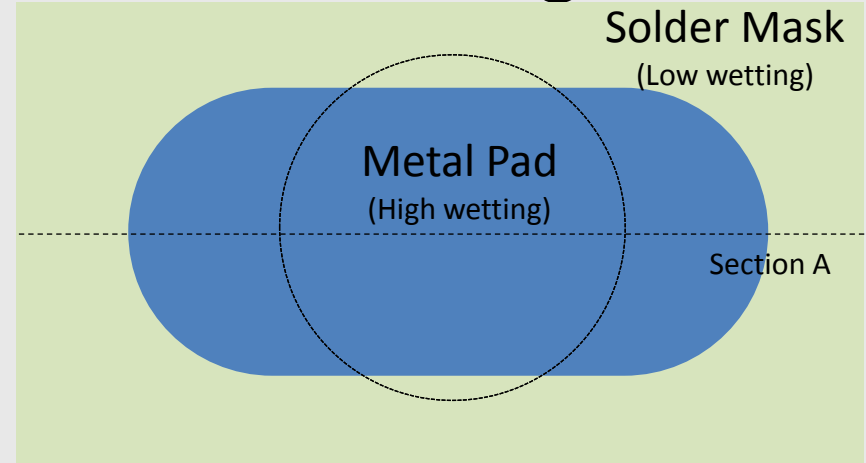
Solder Reflow and Manufacturing

Solder is deposited as a paste onto a metallic pad with surrounding passivation.

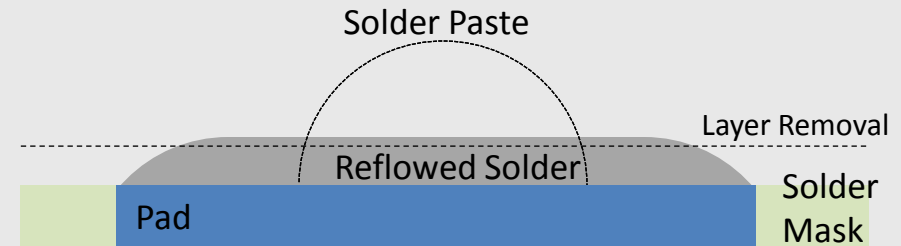
During high temperature reflow, liquid solder shape is influenced by surface tension, gravity and wall contact angles.

Solidified solder is encapsulated then a layer is removed to expose a flat plane for connections.

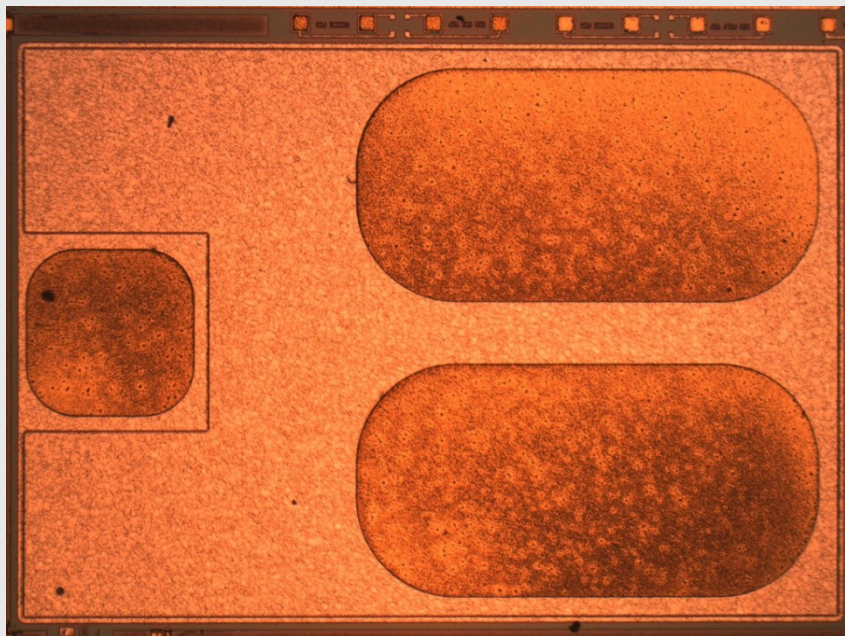
Predict the cross-sectional area of exposed solder



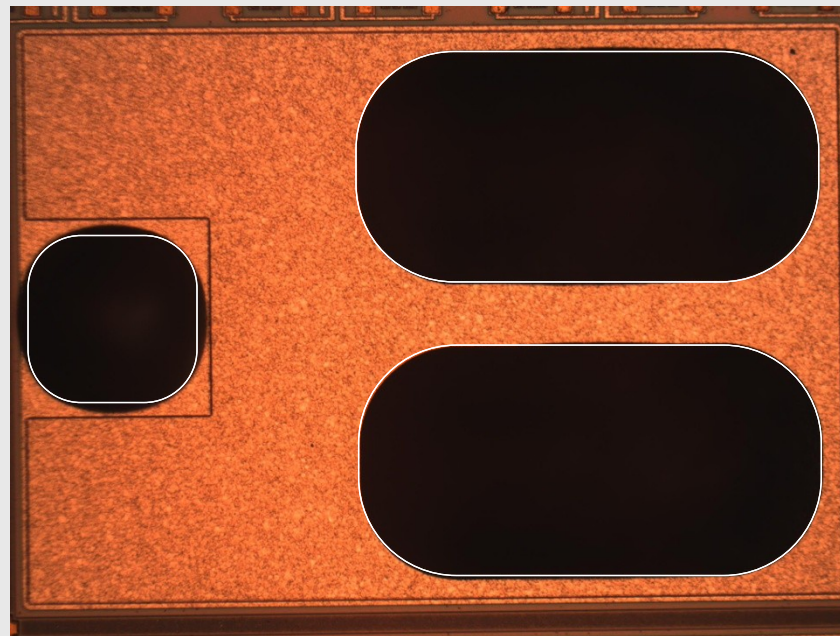
Top View: Pad, Solder Mask, Paste outline



Side View (Section A): Assembly

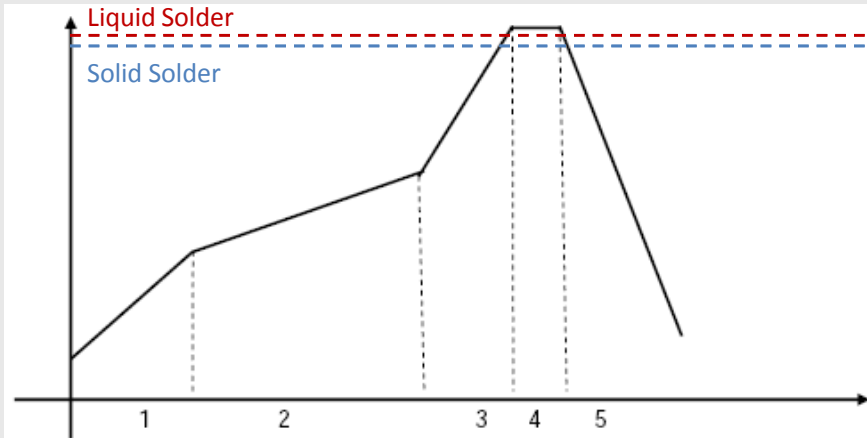


Bare metallic pads before solder reflow.



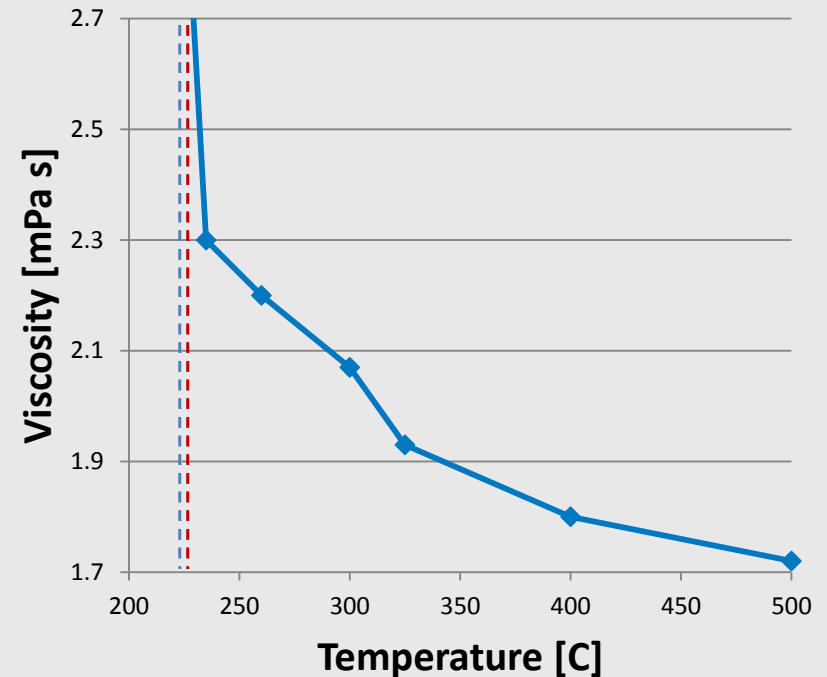
Solder over metallic pads after reflow.

Reflow Properties



Profile Feature	Requirement
1. Ramp up	1-4°C/second
2. Soak	150°C ~200°C 60-180 seconds
3. Ramp up	1-4°C/second
4. Peak soak	245~260°C 10 seconds max.
5. Ramp-down rate	1~6°C/second max.

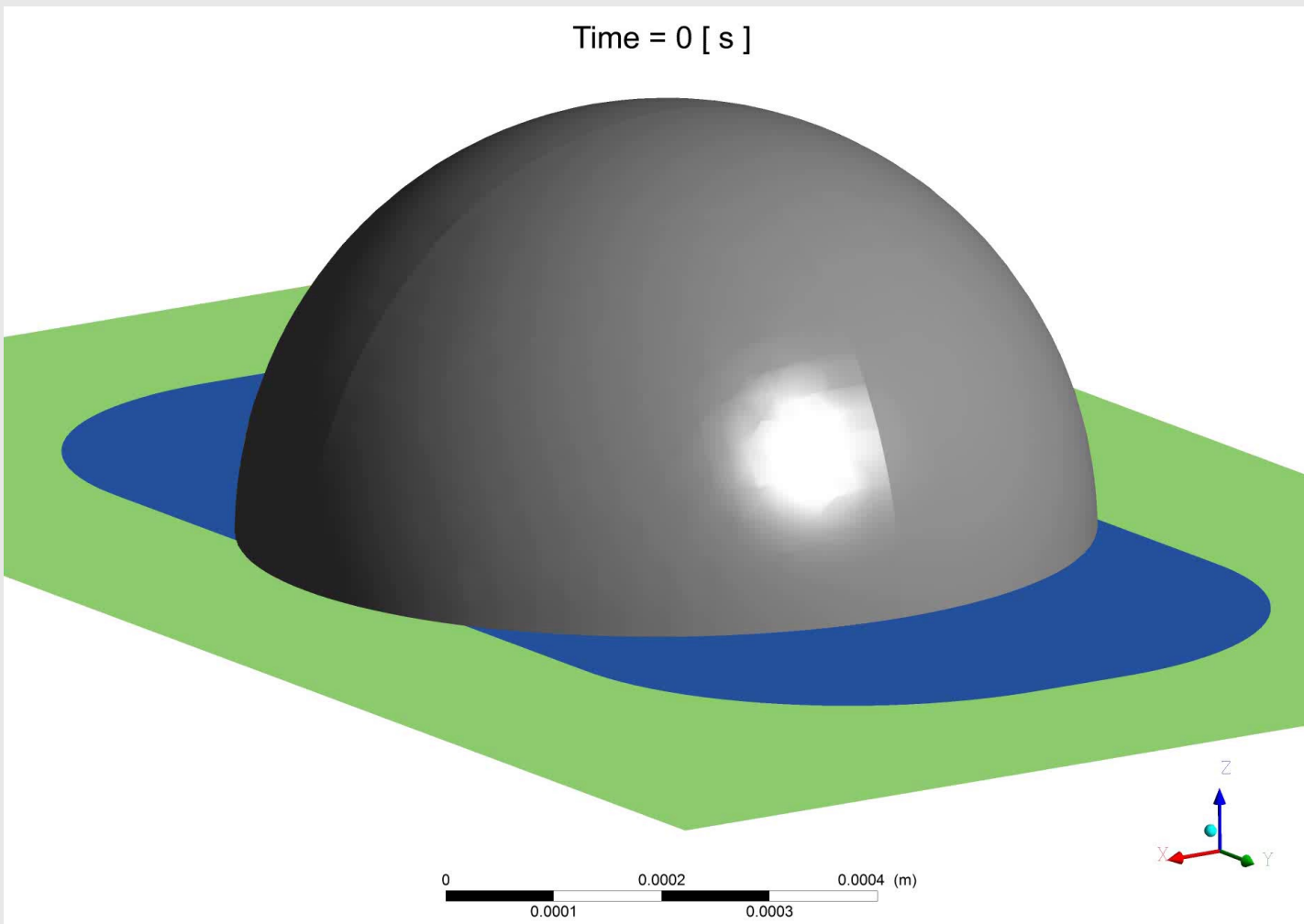
Solder Viscosity vs. Temperature



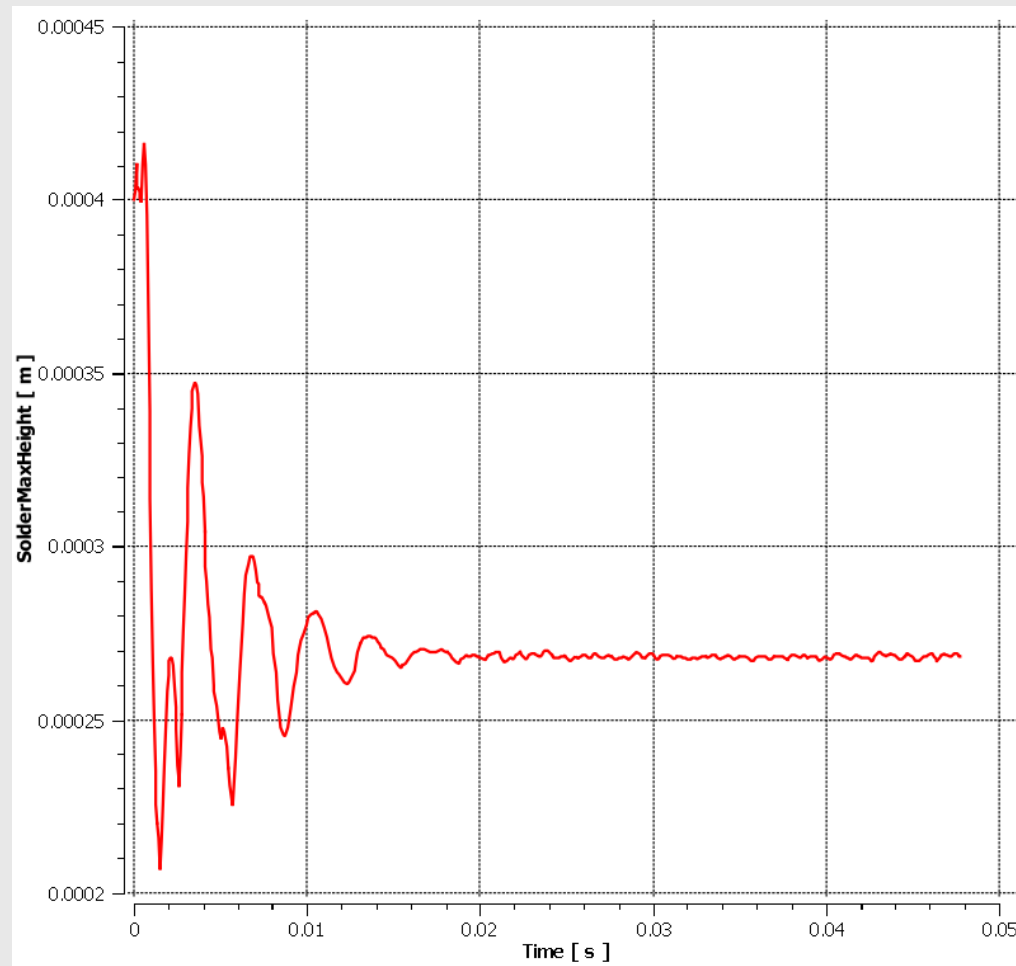
Generic solder reflow manufacturing specifications.

Generic solder viscosity profile from Ning, Viscosities and Wetting Behaviors of Sn-Cu Solders, 2012.

Animation – Solder Reflow



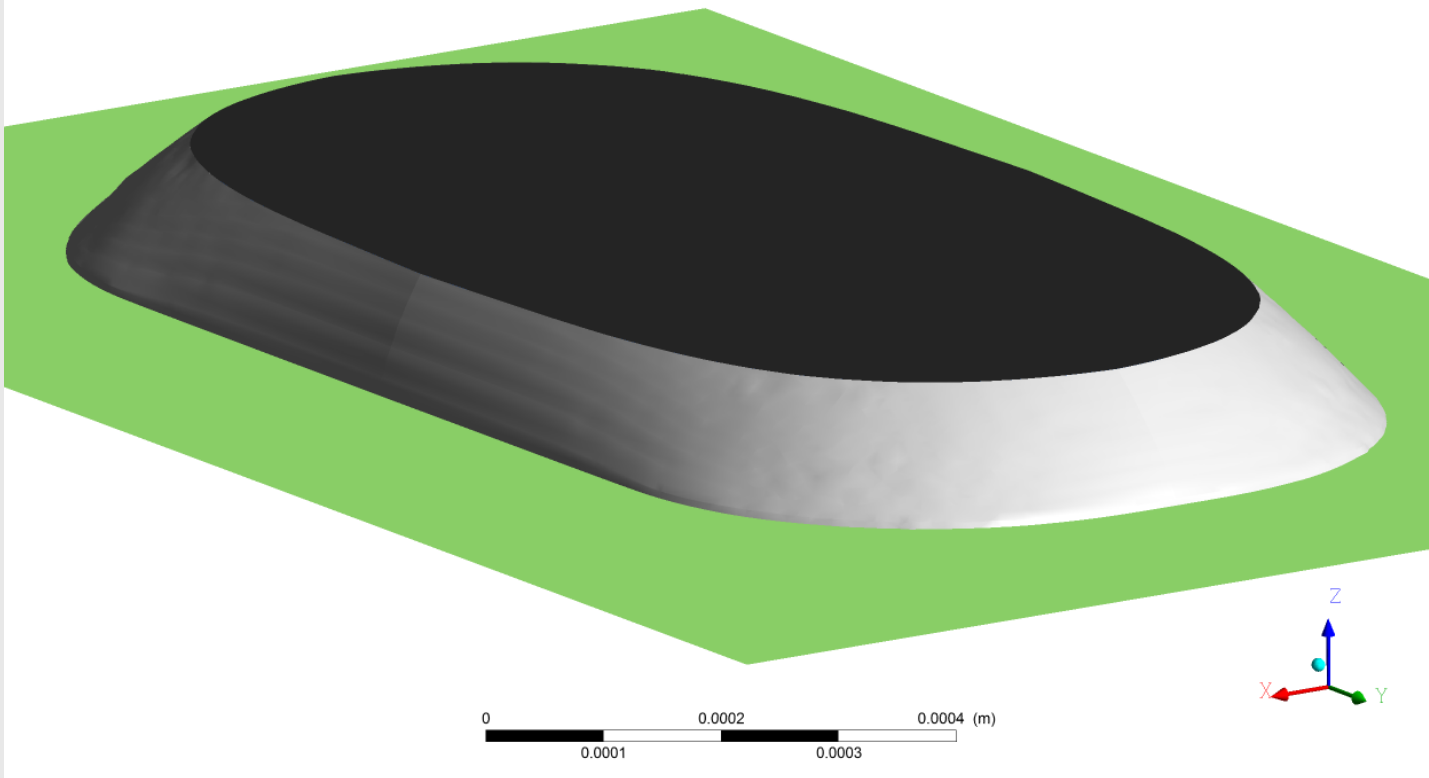
IsoSurface at Solder Boundary



Maximum Solder Height vs. Time

Exposed Solder Area

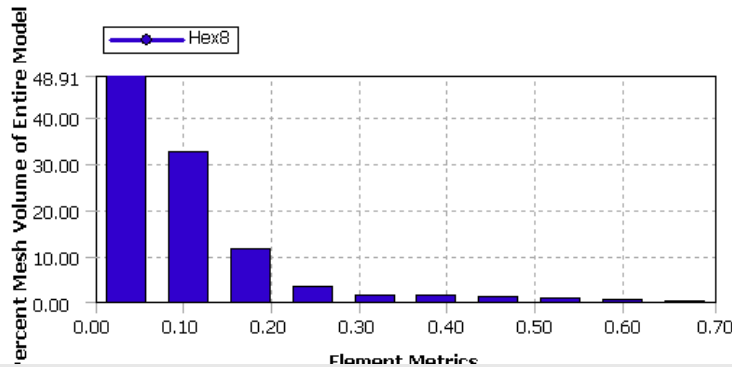
Time = 0.0250051 [s]
Exposed Area = 1.58788e-007 [m^2]



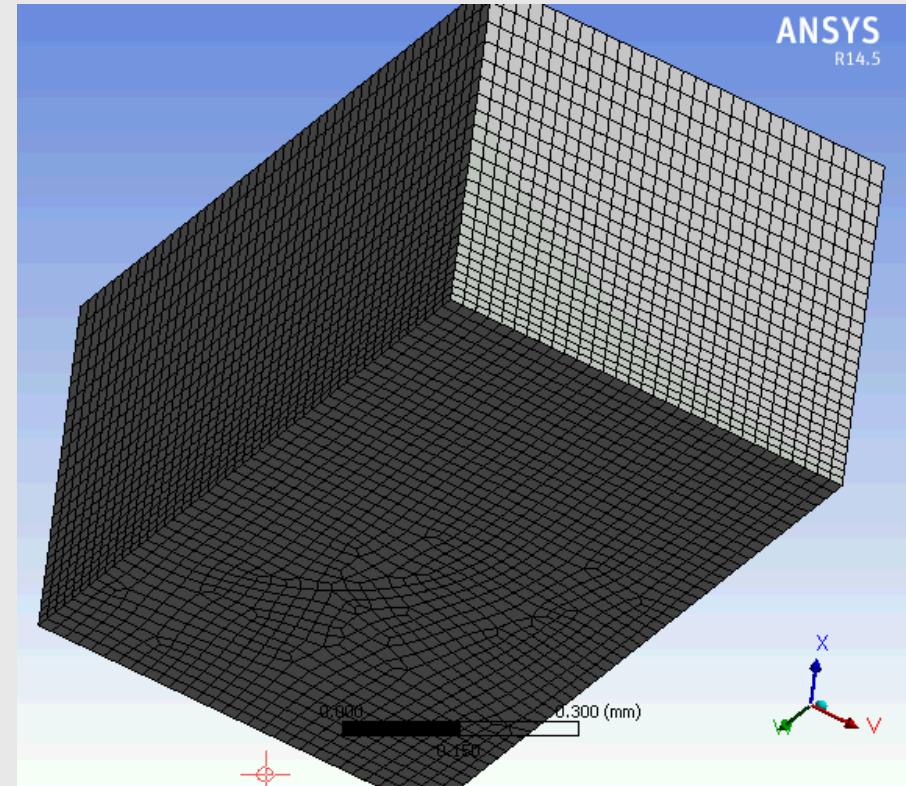
Uniform sized hex elements

Gradual transition from refined regions

Low skewness & aspect ratio

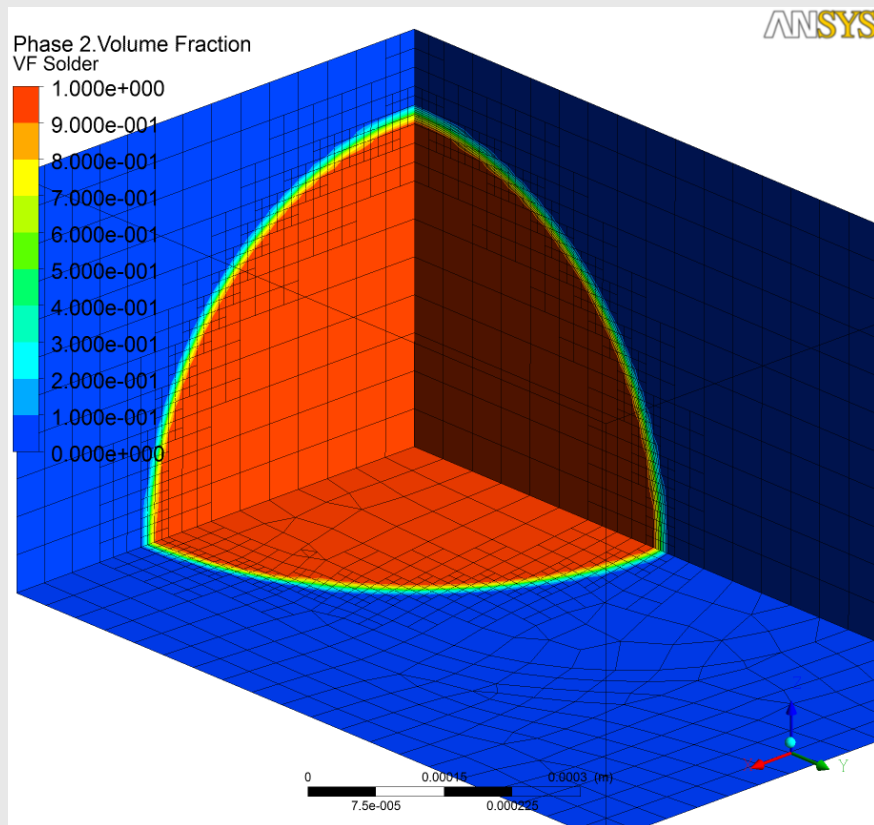


Recommendations from ANSYS Knowledge Resources

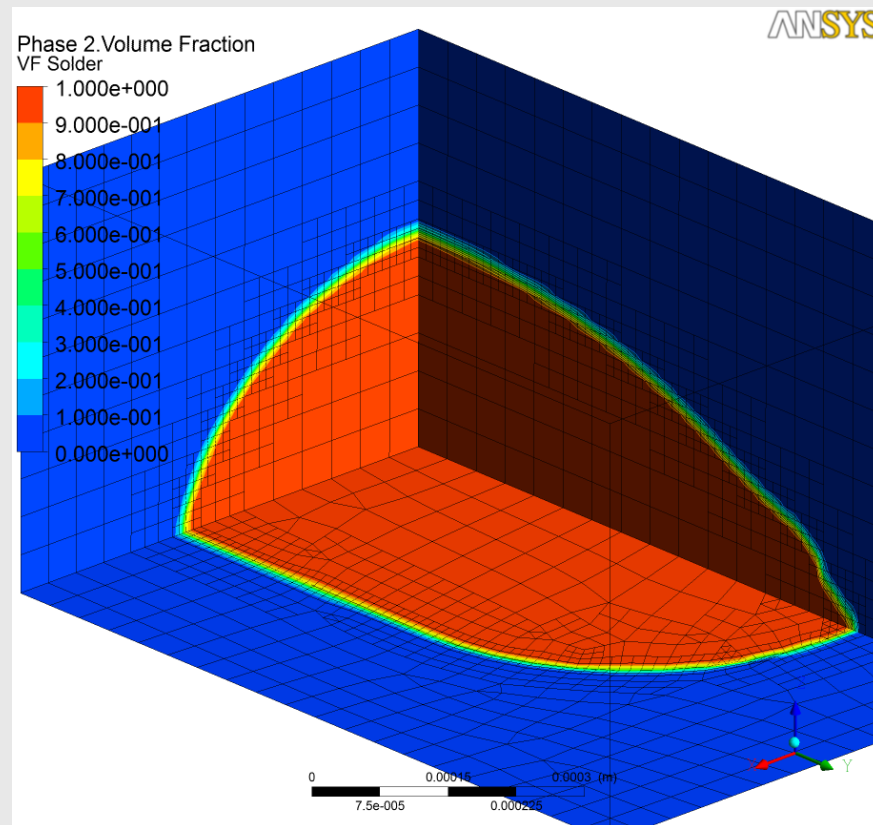


Skewness

Adaptive Meshing

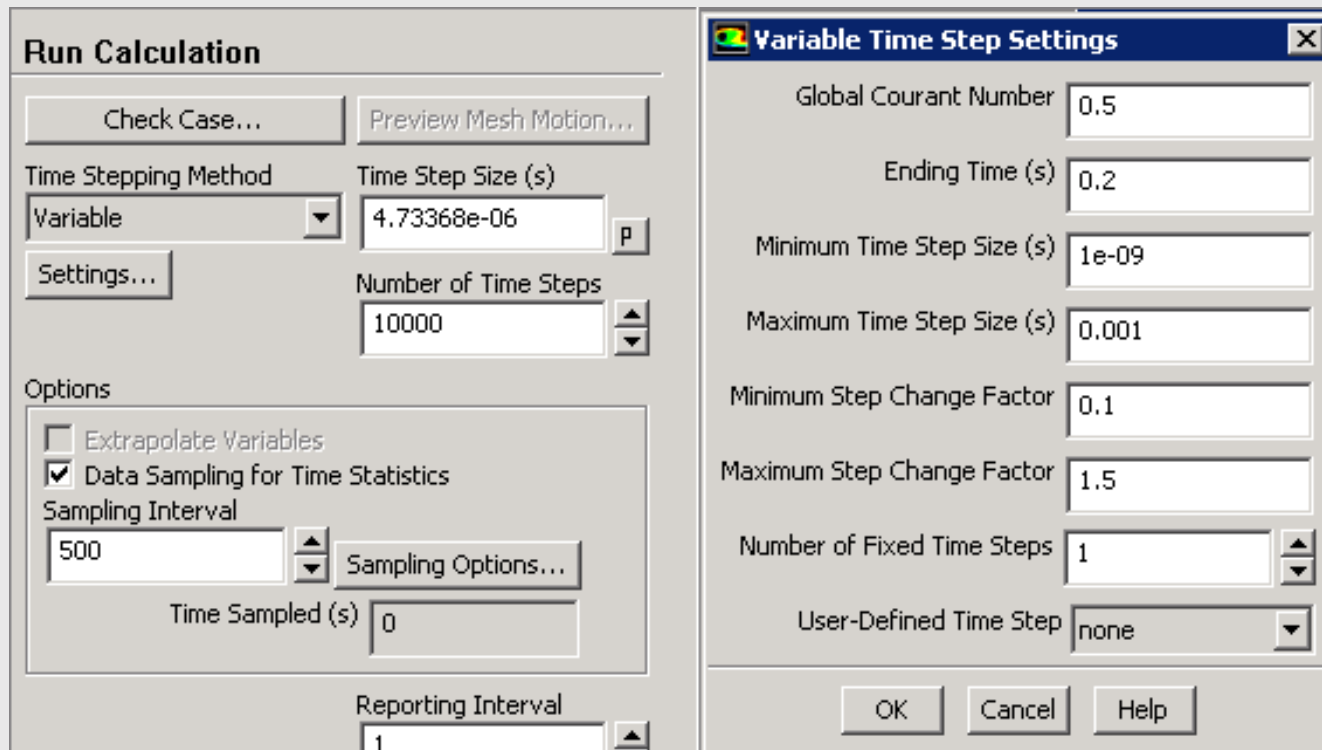


Time = 0 ms



Time = 13 ms

Time Stepping



The image shows two dialog boxes from the ANSYS software. The 'Run Calculation' dialog box on the left has a 'Time Stepping Method' dropdown set to 'Variable', a 'Time Step Size (s)' of 4.73368e-06, and a 'Number of Time Steps' of 10000. It also includes an 'Options' section with checkboxes for 'Extrapolate Variables' (unchecked) and 'Data Sampling for Time Statistics' (checked), along with a 'Sampling Interval' of 500 and a 'Time Sampled (s)' of 0. The 'Variable Time Step Settings' dialog box on the right is titled 'Variable Time Step Settings' and contains fields for 'Global Courant Number' (0.5), 'Ending Time (s)' (0.2), 'Minimum Time Step Size (s)' (1e-09), 'Maximum Time Step Size (s)' (0.001), 'Minimum Step Change Factor' (0.1), 'Maximum Step Change Factor' (1.5), 'Number of Fixed Time Steps' (1), and 'User-Defined Time Step' (none). Both dialog boxes have 'OK', 'Cancel', and 'Help' buttons at the bottom.

Run Calculation

Check Case... Preview Mesh Motion...

Time Stepping Method: Variable

Time Step Size (s): 4.73368e-06

Settings...

Number of Time Steps: 10000

Options

☐ Extrapolate Variables

☒ Data Sampling for Time Statistics

Sampling Interval: 500

Sampling Options...

Time Sampled (s): 0

Reporting Interval: 1

Variable Time Step Settings

Global Courant Number: 0.5

Ending Time (s): 0.2

Minimum Time Step Size (s): 1e-09

Maximum Time Step Size (s): 0.001

Minimum Step Change Factor: 0.1

Maximum Step Change Factor: 1.5

Number of Fixed Time Steps: 1

User-Defined Time Step: none

OK Cancel Help

Variable Time Stepping

Global Courant Number

Data Sampling

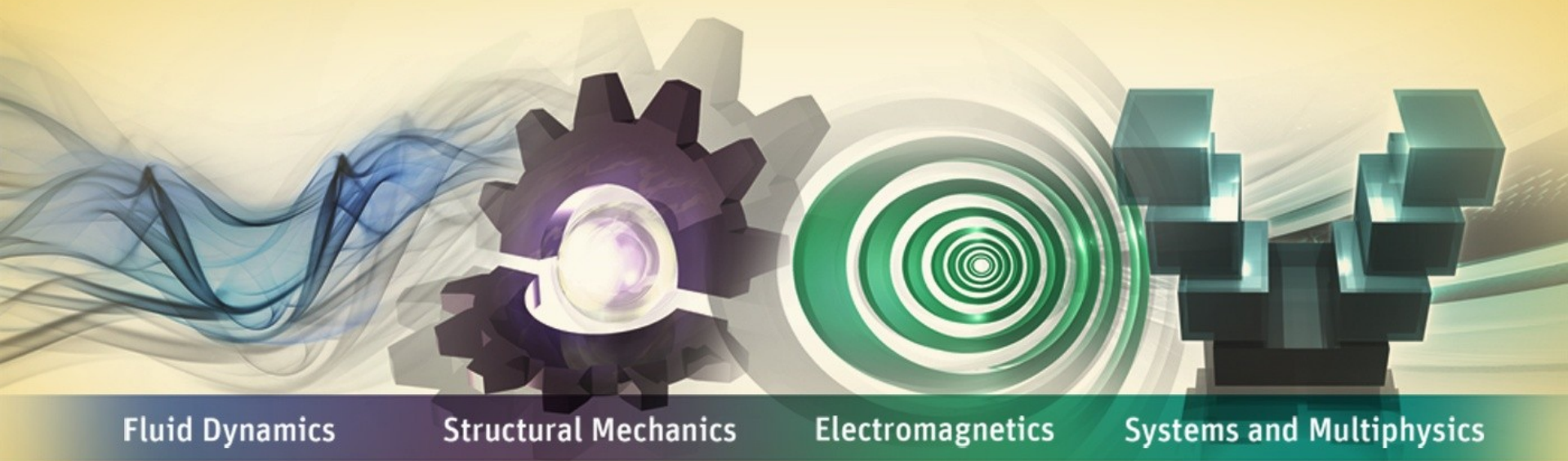


Realize Your Product Promise[®]

END

Thanks for your attention !!!

Questions ?



CONTACT:
ATTENTION: Chris Cowan
OZEN ENGINEERING, INC.

1210 E. ARQUES AVE. SUITE: 207
SUNNYVALE, CA 94085
(408) 732-4665
info@ozeninc.com
www.ozeninc.com