PYRO DYNAMICS

APPLICATION NOTES
HIGH SPEED DIC

Correlated Solutions Inc VIC-3D , 3D - Digital Image Correlation

For Non Contact Full Field Displacement and Strain Measurement

And Modal Analysis.

A Brief Application Note on the Tests Carried out by Pyrodynamics

At Various Organizations in India using VIC-3D, 3D DIC System.

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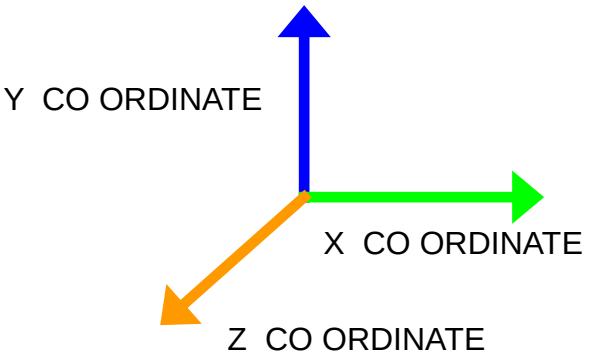
DIC Measures Displacements.

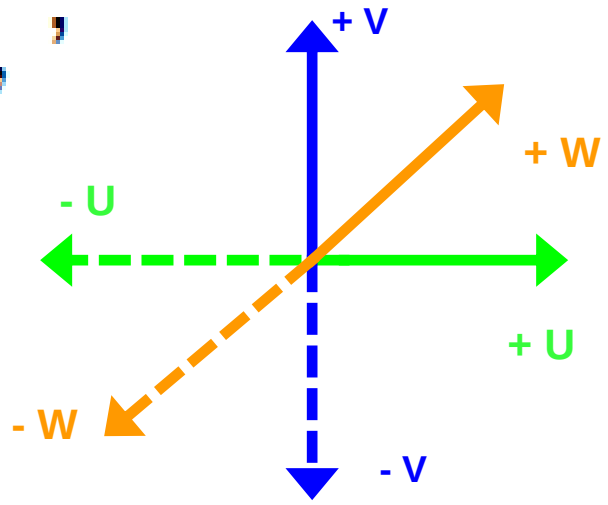
Strain is a Derivative of Displacement. Lagrange Strain tensor is used for calculation of Strains

Calculation of strains:



$$\varepsilon_x = \frac{\partial u}{\partial x}, \qquad \varepsilon_y = \frac{\partial v}{\partial y},$$

$$\gamma_{xy} = \frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}$$



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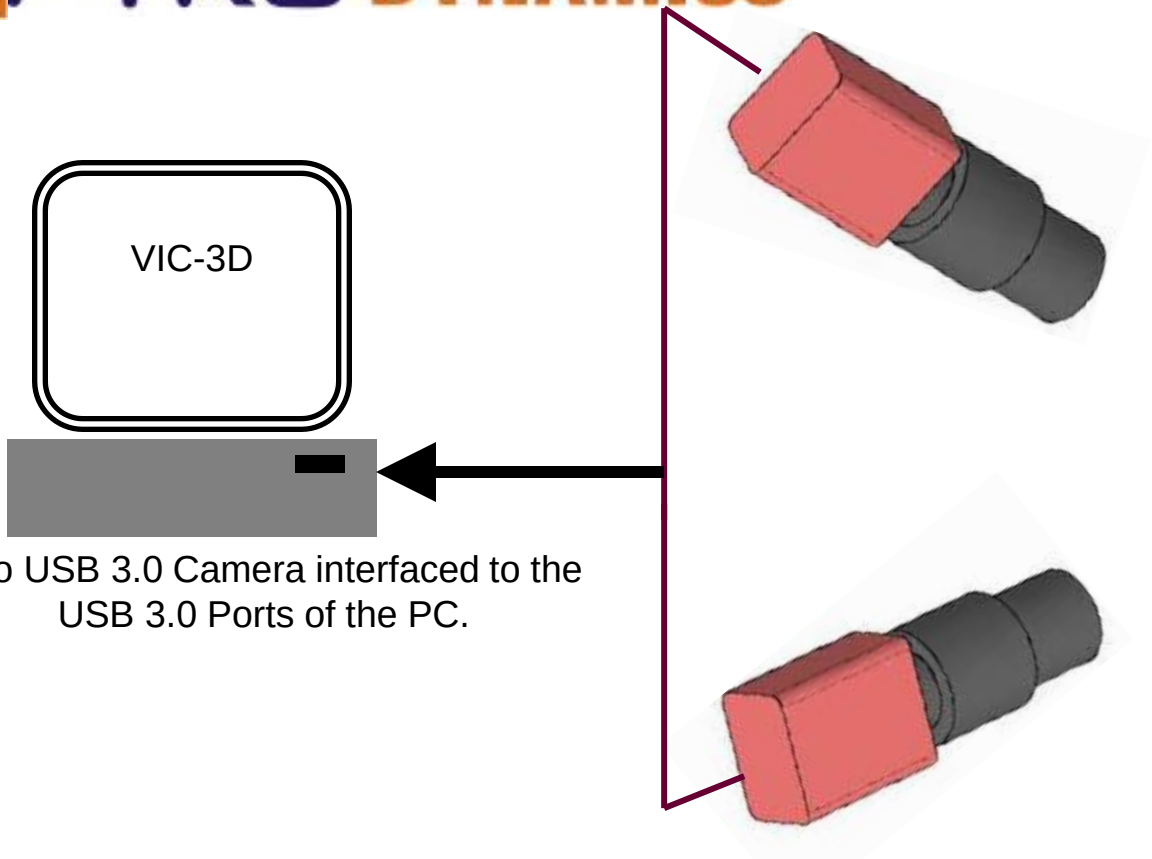
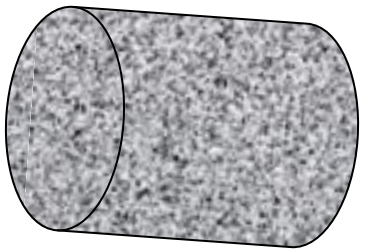
VIC- 3D, 3D Digital Image Correlation System.



Two USB 3.0 Camera interfaced to the USB 3.0 Ports of the PC.



Displacement and Strain Measurement In-Plane Direction
(X and Y Direction)
And
Out of Plane Direction
(Z Direction)

Results Obtained from 3D Digital Image Correlation

Contour Co Ordinates:- X, Y and Z ; Displacement:- u, v and w.

Strains:- ε_{xx} , ε_{yy} , ε_{xy} , ε_1 , ε_2 , Von Mises, Tresca

and Directions of Principal Strains

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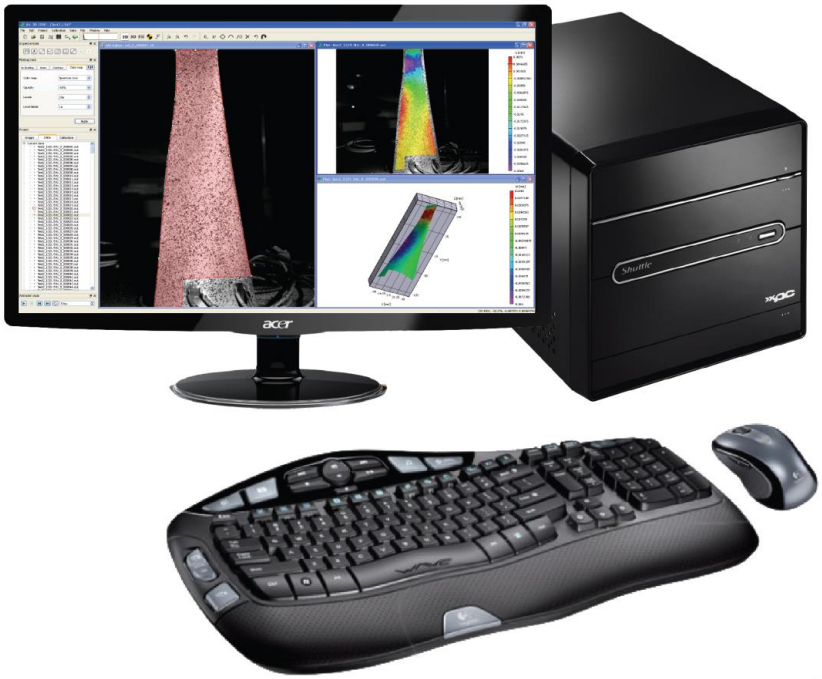
VIC-3D-UHS SYSTEM



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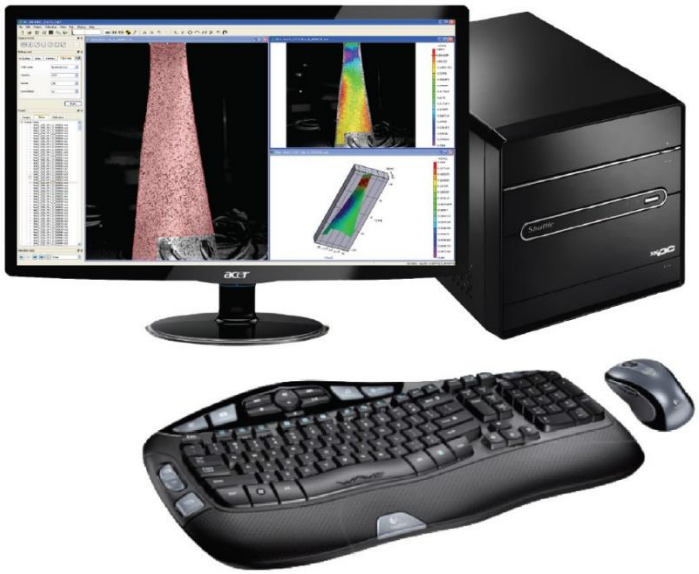
VIC-3D-HS SYSTEM

The VIC-3D HS Digital Image Correlation Measurement System



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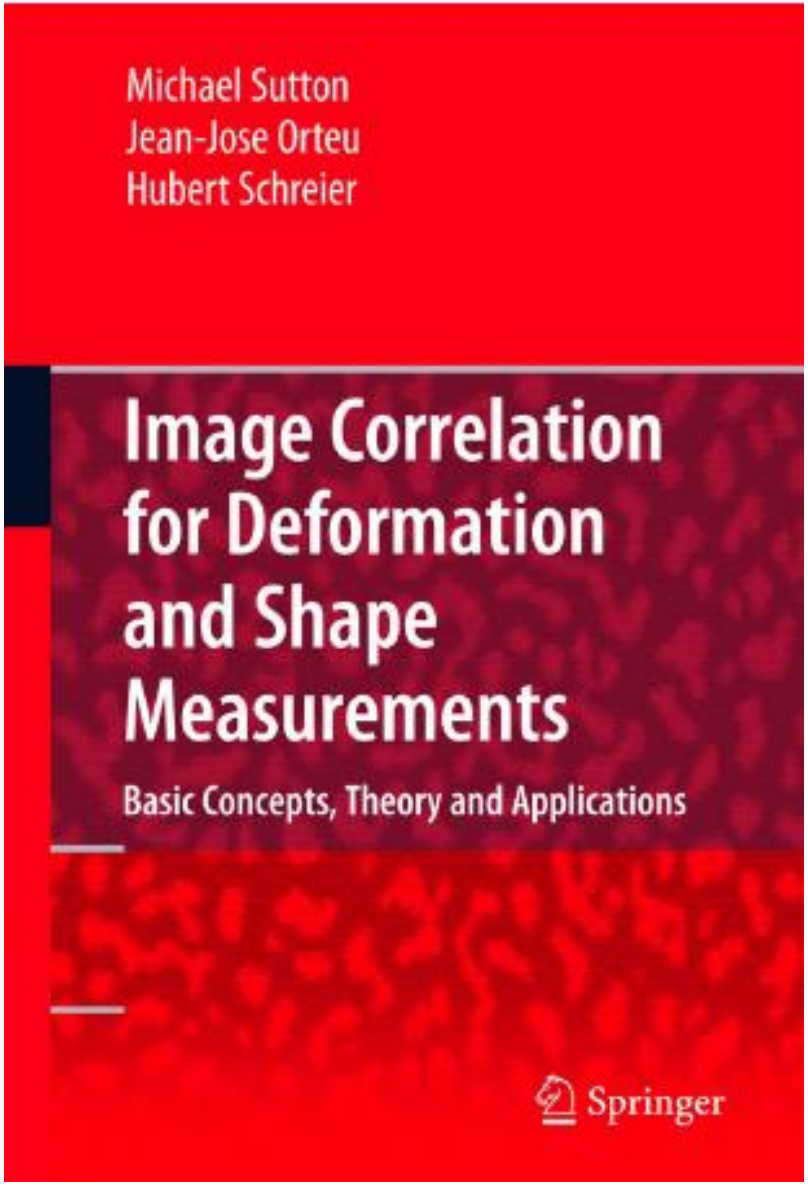
Michael Sutton
Jean-Jose Orteu
Hubert Schreier
Image Correlation for Deformation and Shape Measurements
Basic Concepts, Theory and Applications
Springer

PYRO DYNAMICS

Experiment	Fatigue Measurements of a Composite Specimen
Organisation	Indian Institute of Technology. Department of Aerospace Engineering. Chennai.
System Used	VIC-2D, 2D Digital Image Correlation System.
Loading Conditions	1 Hz Cyclic Loading upto failure. Measurements carried out in the front and back of the specimen using Two VIC-2D Systems.
Camera Used	Prosilica 2MP Camera, 63fps
Image Frame Capture	60 images in one second and a hold period of 100 seconds. This image capture is looped.

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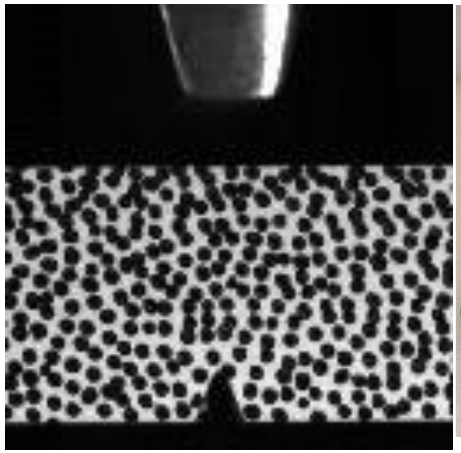
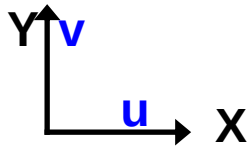
A speckle pattern was applied on the charpy test specimen.

The specimen was first spray painted by a white paint. The speckles was marked using a marker pen.

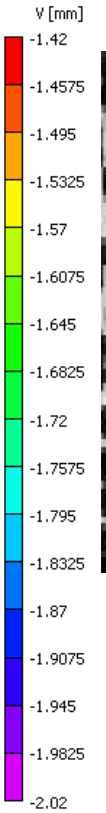
Images were captured at 20,000 fps using a Phantom Camera.

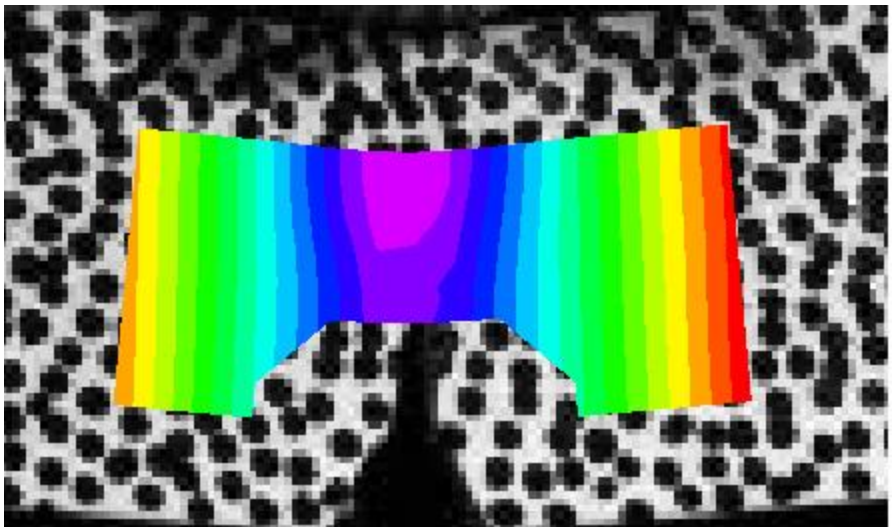
Image Resolution was 128 x 624 pixels. A subset of 25 pixels Was used for correlation.





U Displacement
Time = **2100** μs





V Displacement
Time = **2100** μs

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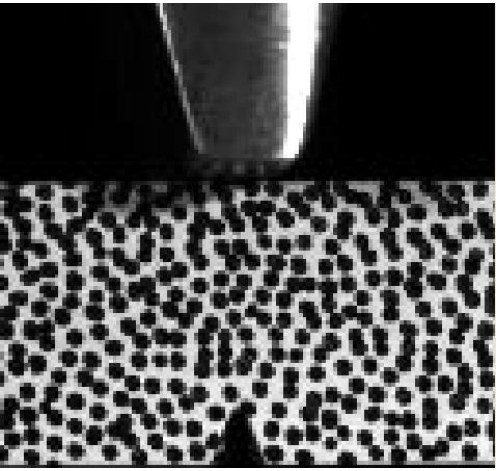
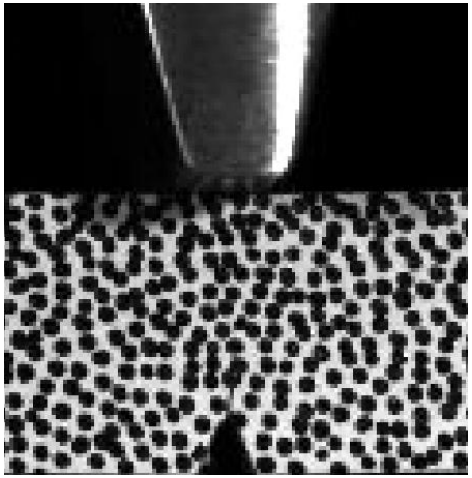
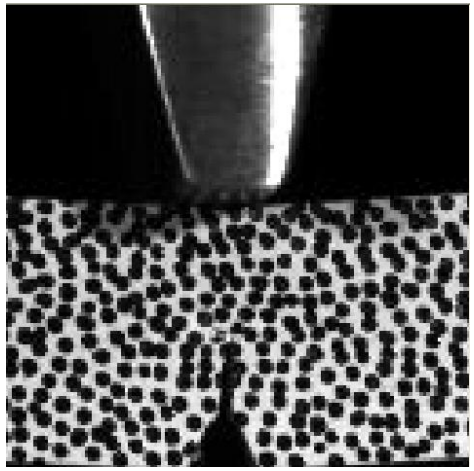
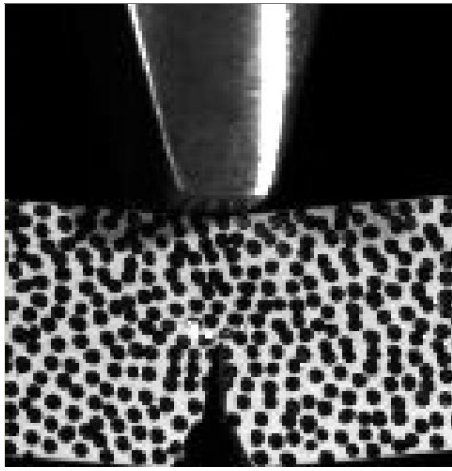
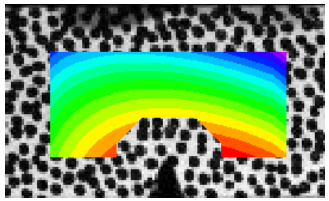
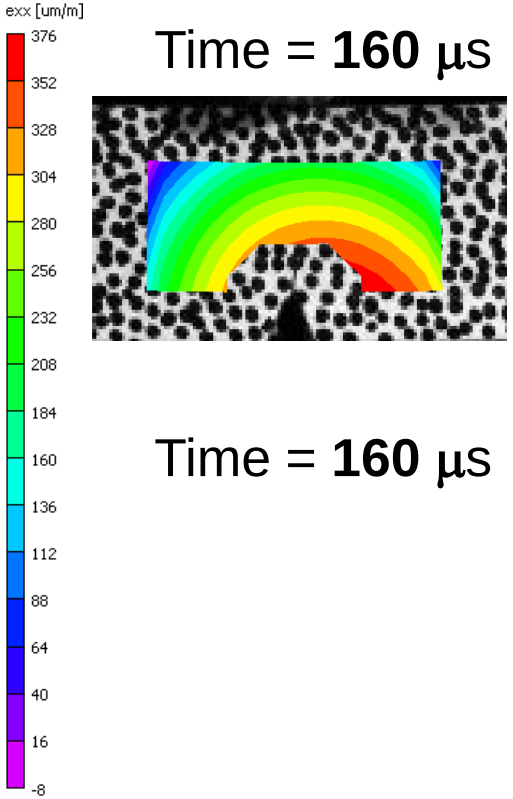
Plot of ε_{xx} at different time intervals.

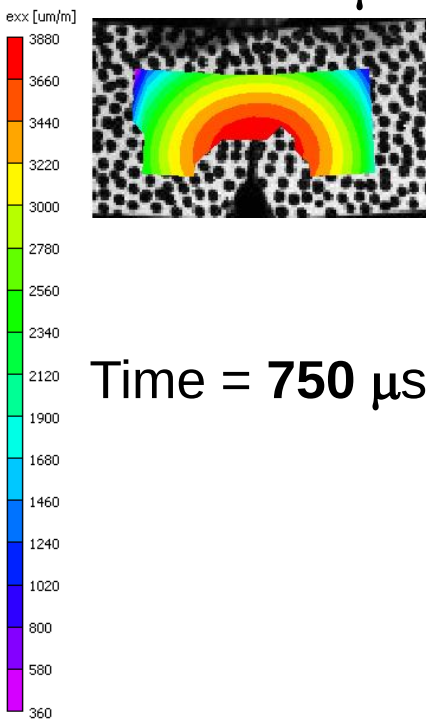
Time = **0** μs





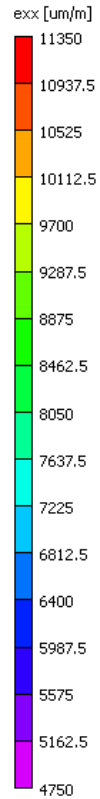
Time = **0** μs

Time = **160** μs



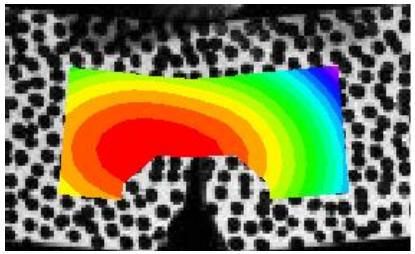
Time = **160** μs

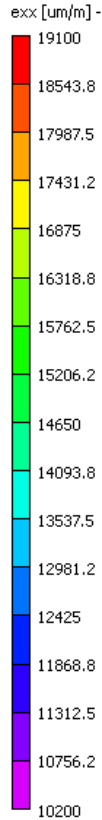
Time = **750** μs



Time = **750** μs

Time = **2100** μs





Time = **2100** μs

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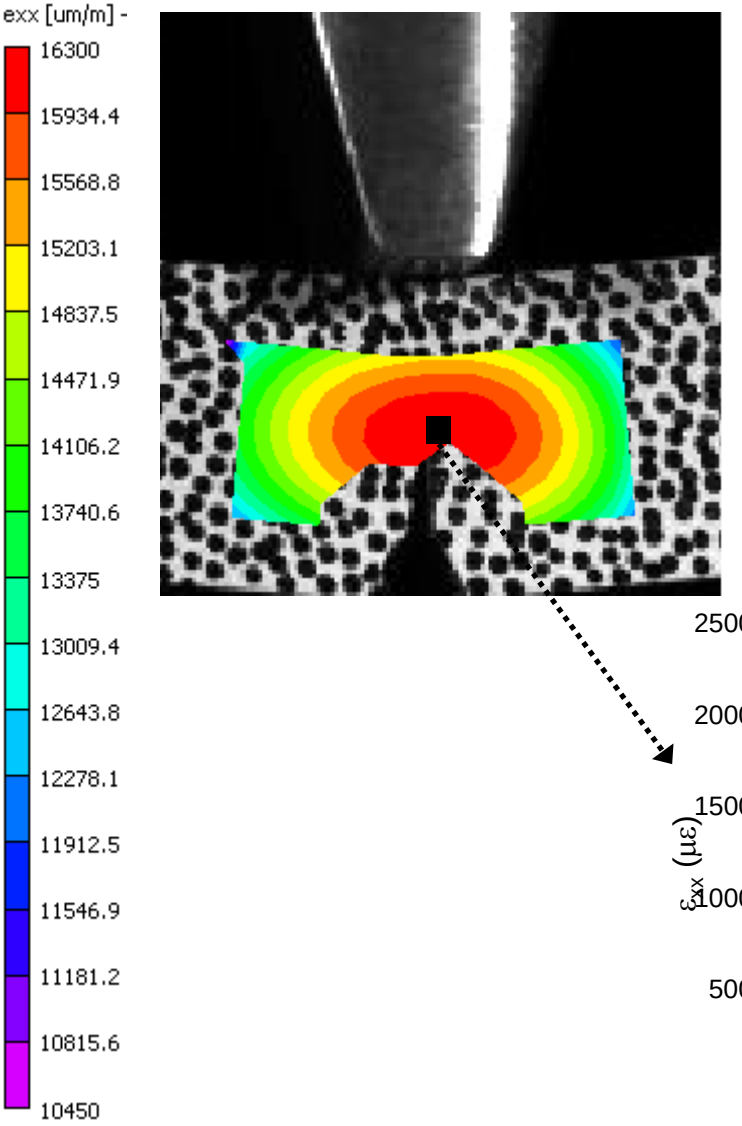

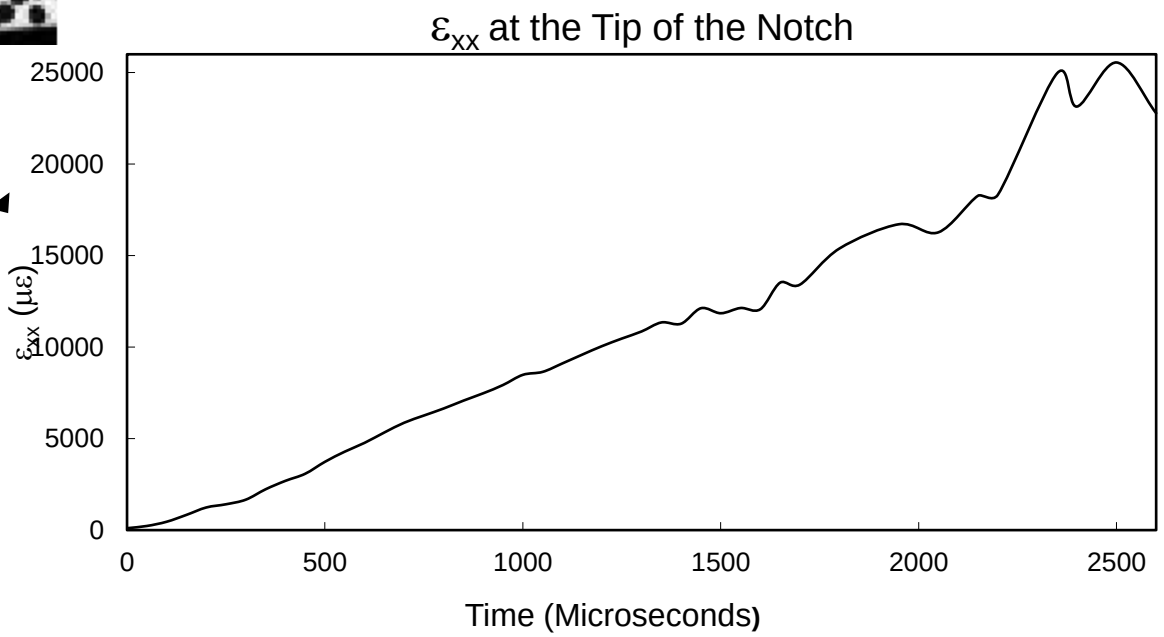

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Experiment	Impact Measurements on a Composite Specimen in a Drop testing Machine
Organisation	Department of Applied Mechanics. Indian Institute of Technology. New Delhi
System Used	VIC-3D, 3D Digital Image Correlation System with Modal Analysis.
Loading Conditions	Impact.
Camera Used	Photron SA5 Cameras.
Image Frame Capture	30,000 fps.

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A speckle pattern was applied on a Composite Specimen.

The specimen was fixed in the fixture of a Dynatup Impact Tester (Drop Testing Machine)

The plunger strikes the specimen at 2 meters/sec.

The ideal condition would be to mount the cameras below the specimen.

However there is no space and due to safety reasons the cameras are mounted outside the machine.

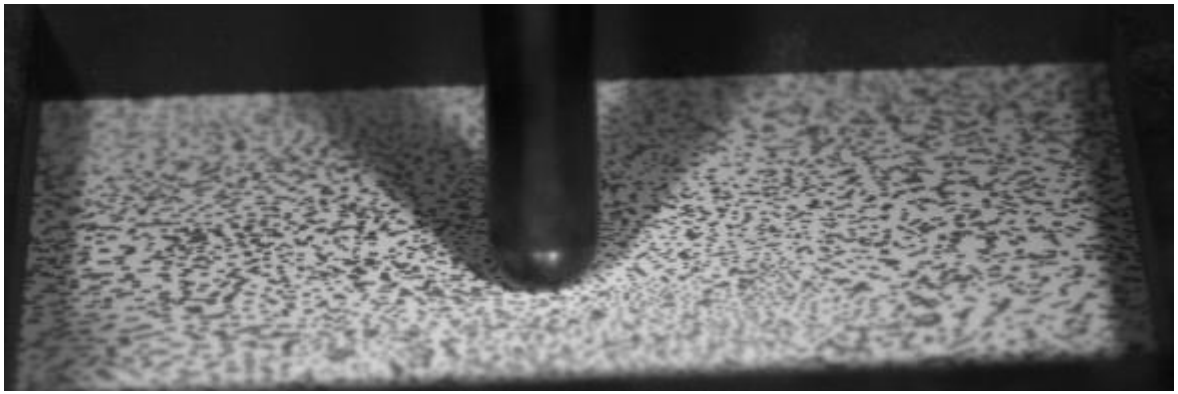
The cameras are mounted at an angle as shown and the specimen is viewed through a glass door.

3D stereo calibration is done using a 12X9X6 Calibration Grid with 6mm spacing.

During calibration, the gris is placed ont he specimen and calibration images captured with the door closed.

Test Images were captured at 30,000 fps

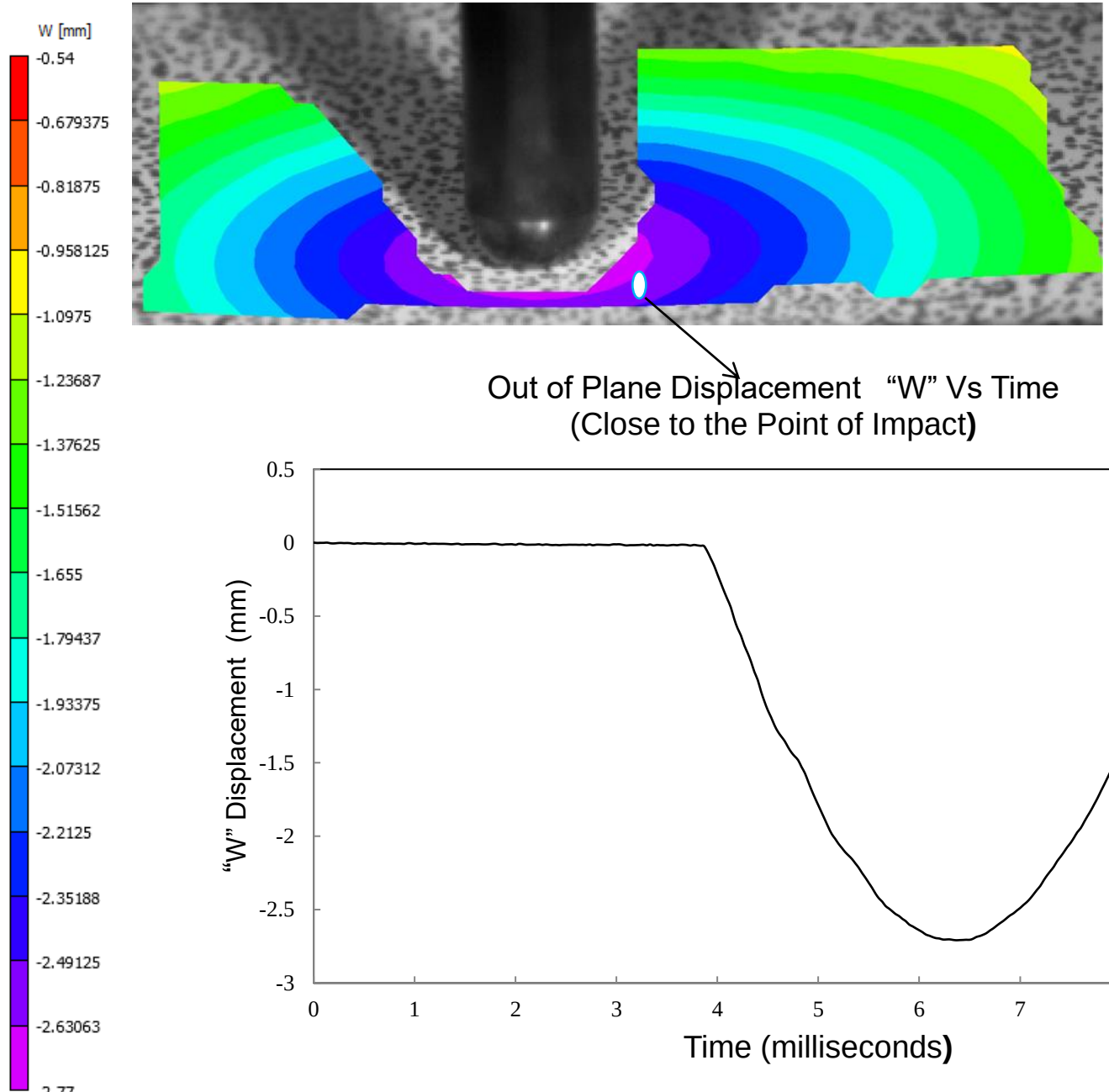
Image Resolution:- 640 X 376 Pixels,



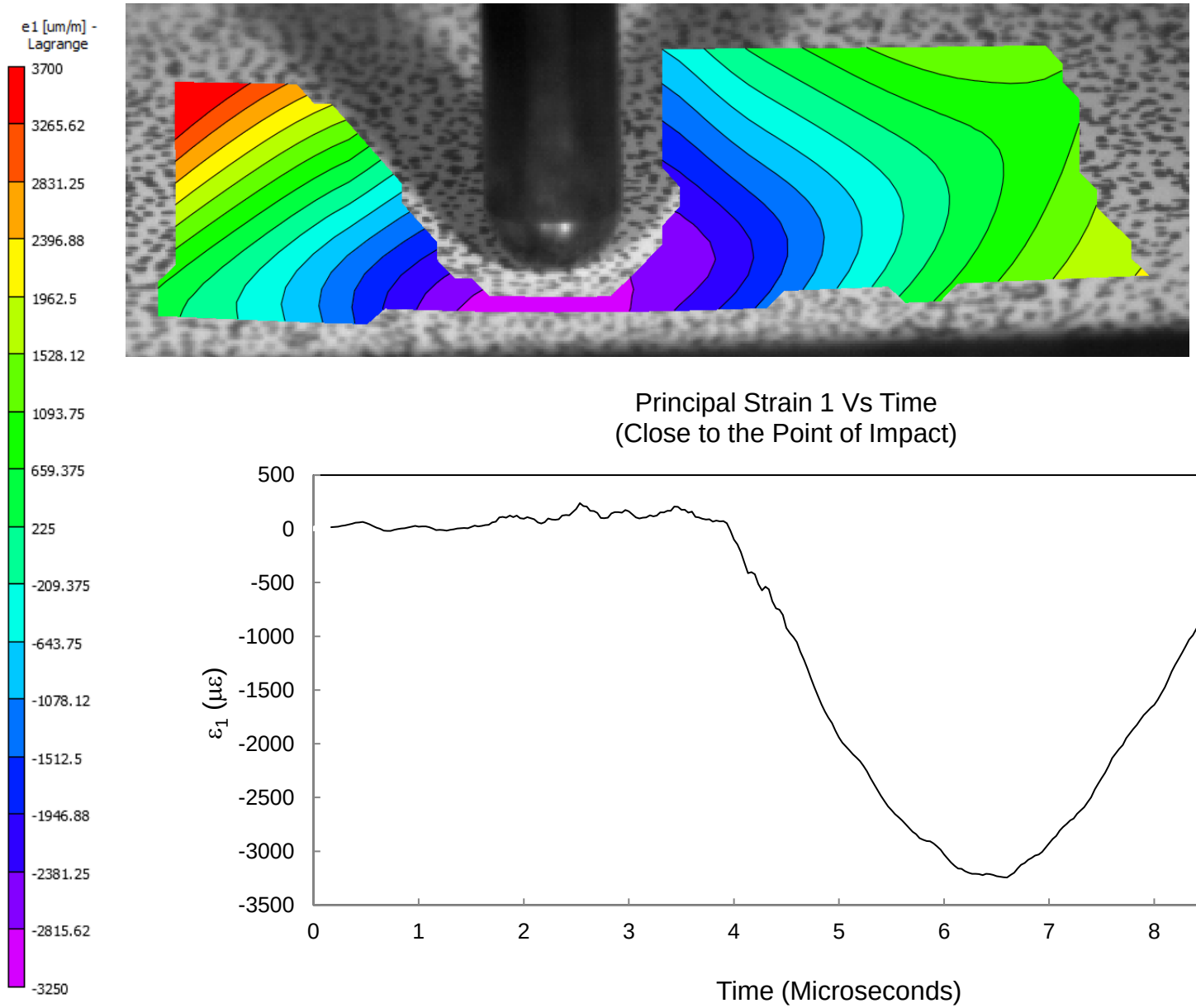
Plunger striking the specimen (Image captured by the camera)

Since the plunger is in the view of the camera, correlation around the plunger is not possible.

PYRO DYNAMICS



Out of Plane Displacement "W" Vs Time
(Close to the Point of Impact)



Principal Strain 1 Vs Time
(Close to the Point of Impact)

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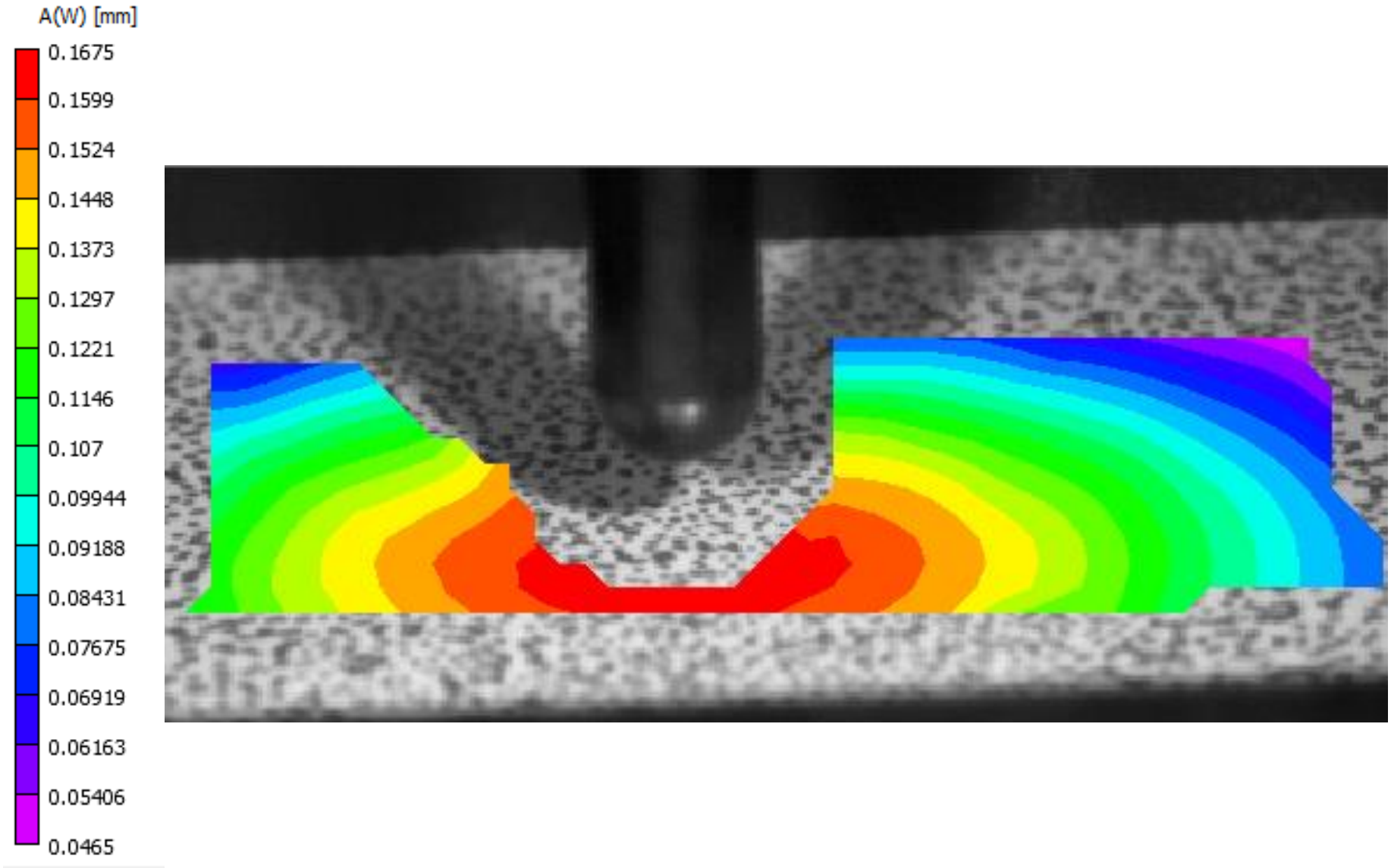
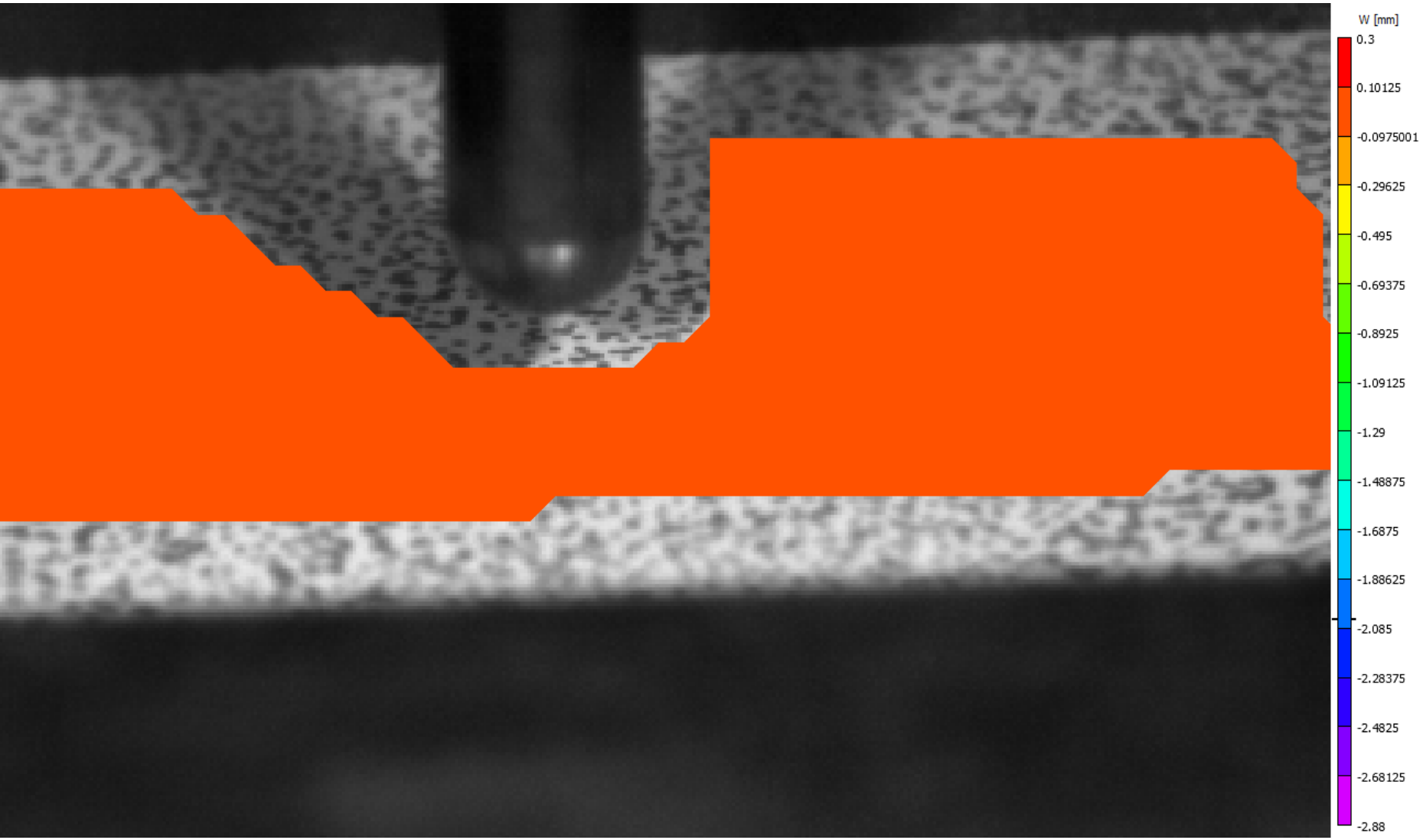
Mode Shape of “W’ Displacement at 381Hz.



PYRO DYNAMICS



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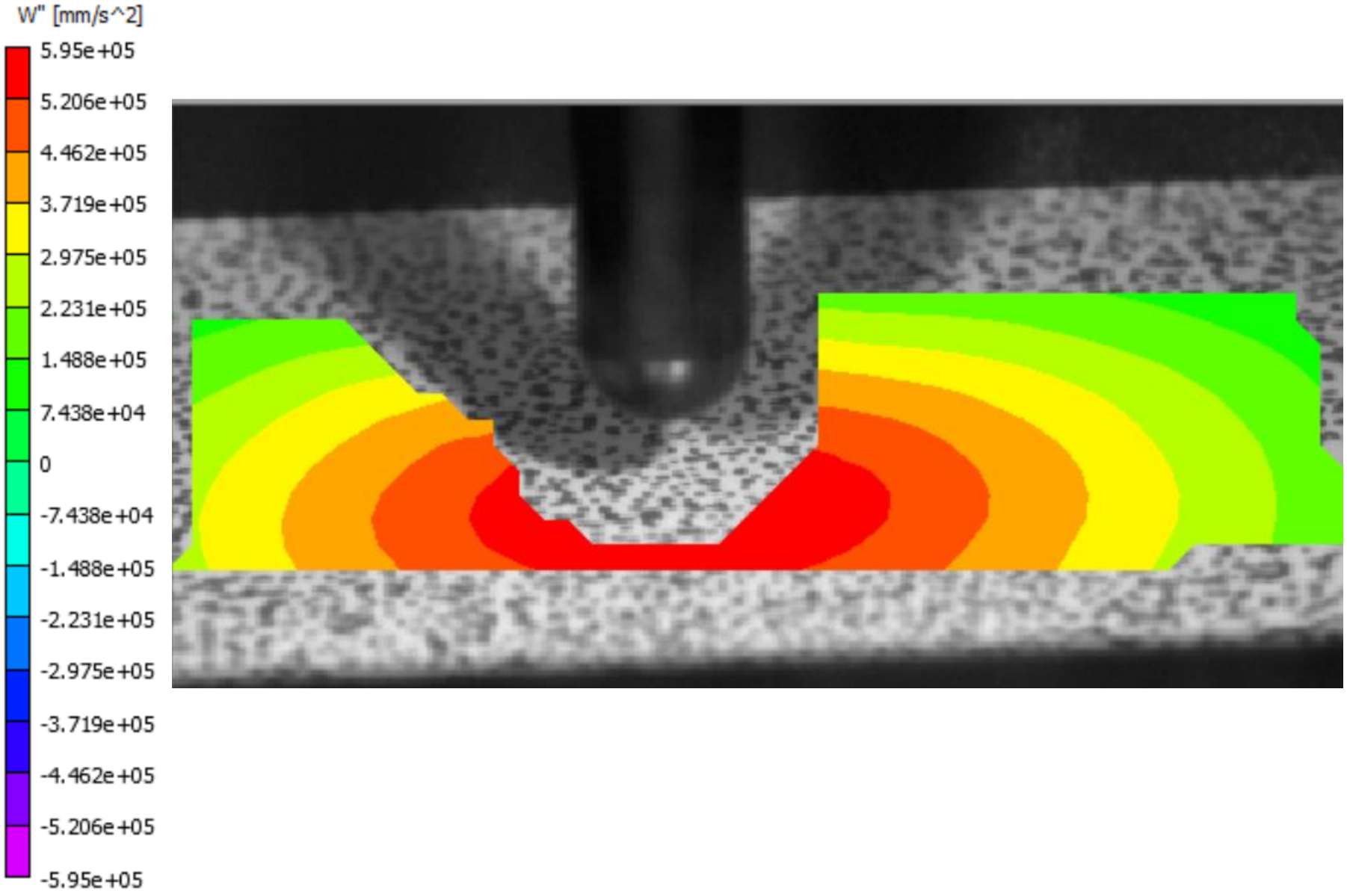
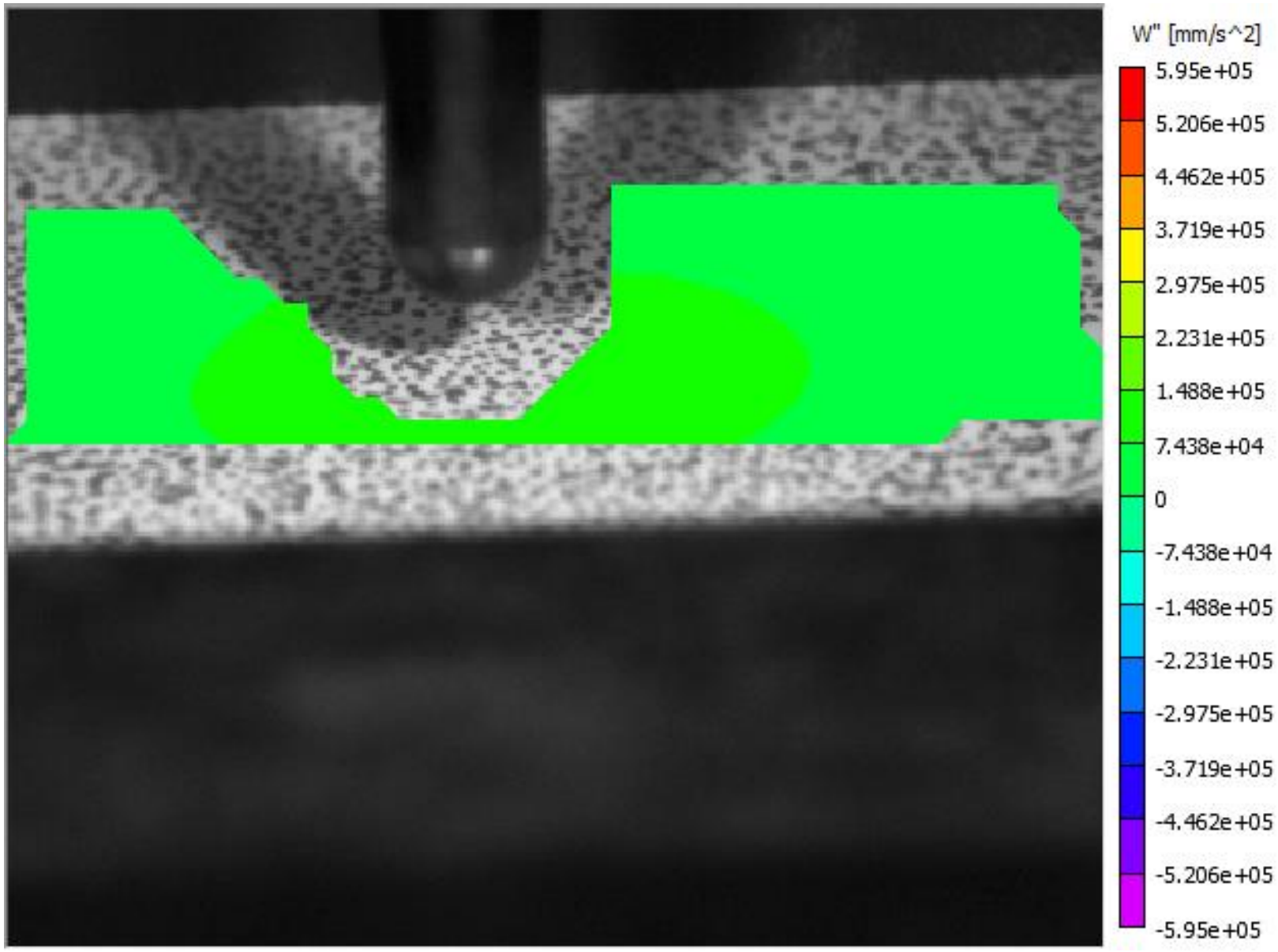
Mode Shape of Acceleration in Z Direction at 800 Hz.

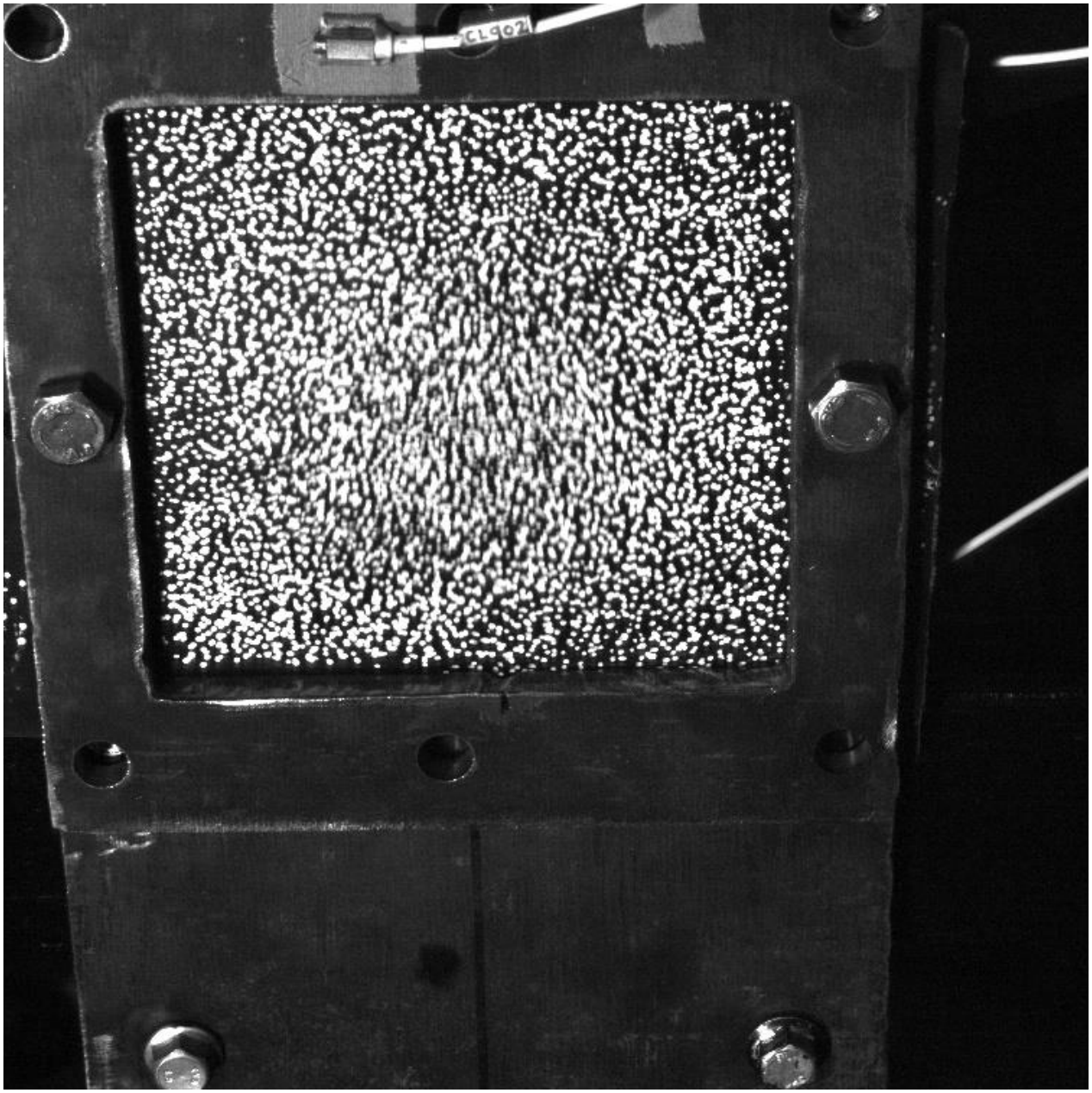



W" [mm/s^2]
5.95e+05
5.206e+05
4.462e+05
3.719e+05
2.975e+05
2.231e+05
1.488e+05
7.438e+04
0
-7.438e+04
-1.488e+05
-2.231e+05
-2.975e+05
-3.719e+05
-4.462e+05
-5.206e+05
-5.95e+05

PYRO DYNAMICS

Experiment	Dash Board of a Car in a Shock Tube
Organisation	Tata Motors Limited Research and Development
System Used	VIC-3D, 3D Digital Image Correlation System with Modal Analysis.
Loading Conditions	Shock Tube
Camera Used	Redlake Cameras.
Image Frame Capture	1,500 fps.

PYRO DYNAMICS



The Test Component is a plastic specimen of 150mm X 150mm.

The specimen was fixed a shock tube and the pressure applied was 6 Bar.

Frame Rate:- 1500 fps

The Test Component was fixed in frame and set close to the exit of the pipe of the shock tube.

When the pressure was applied the rig moved and there by created a rigid body motion.

The VIC-3D is capable of calculating the Rigid Body Motions.

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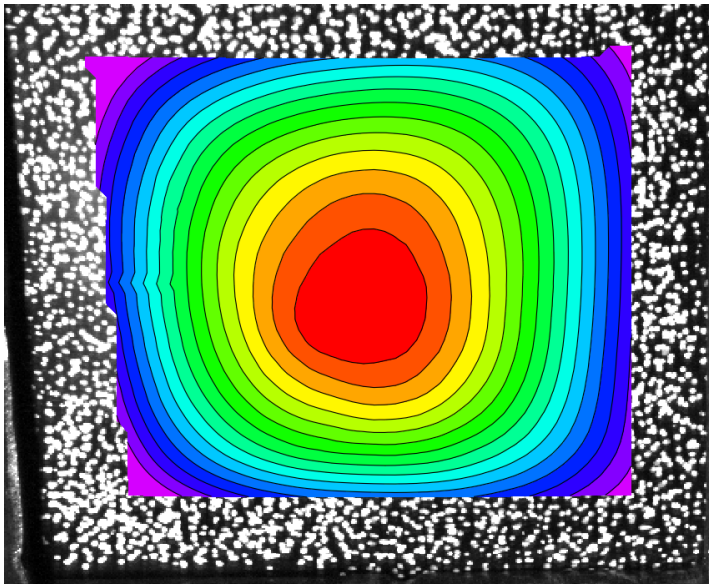
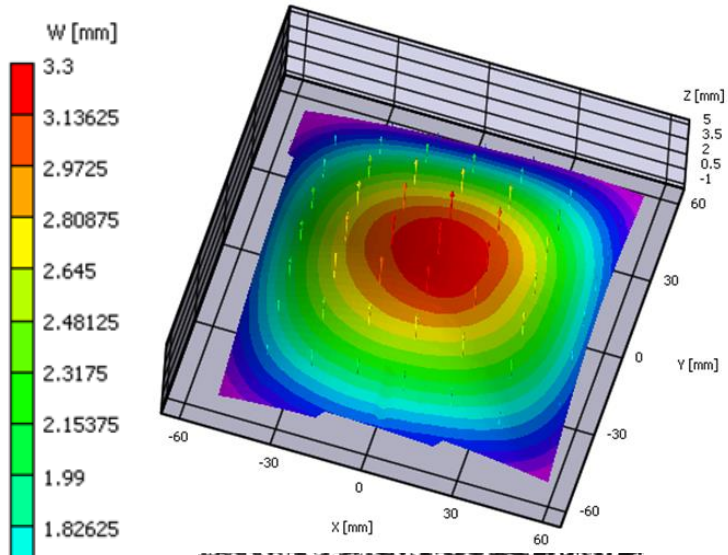
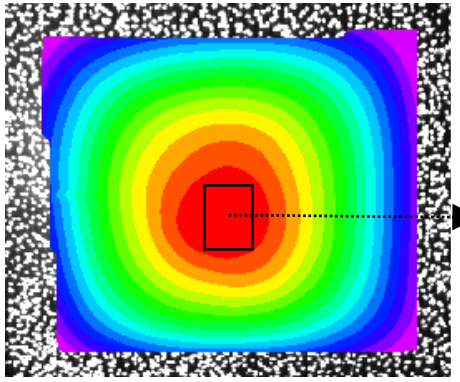
"W" With Rigid Body Motion_Removed. Time:- 0.66 ms





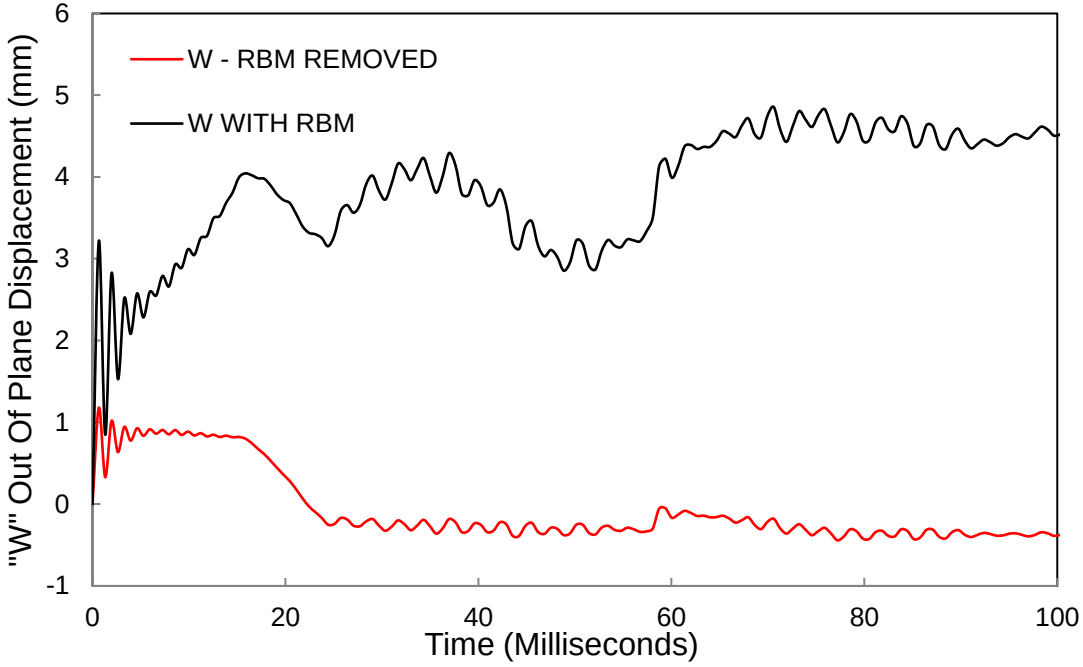


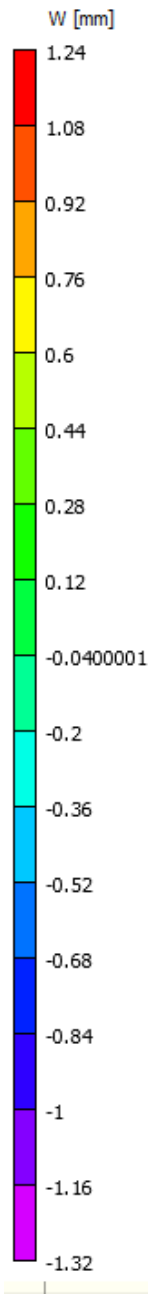
Out of Plane Displacement "W"

With Rigid Body Motion.

Time:- 0.66 ms

Out of Plane Displacement Vs Time





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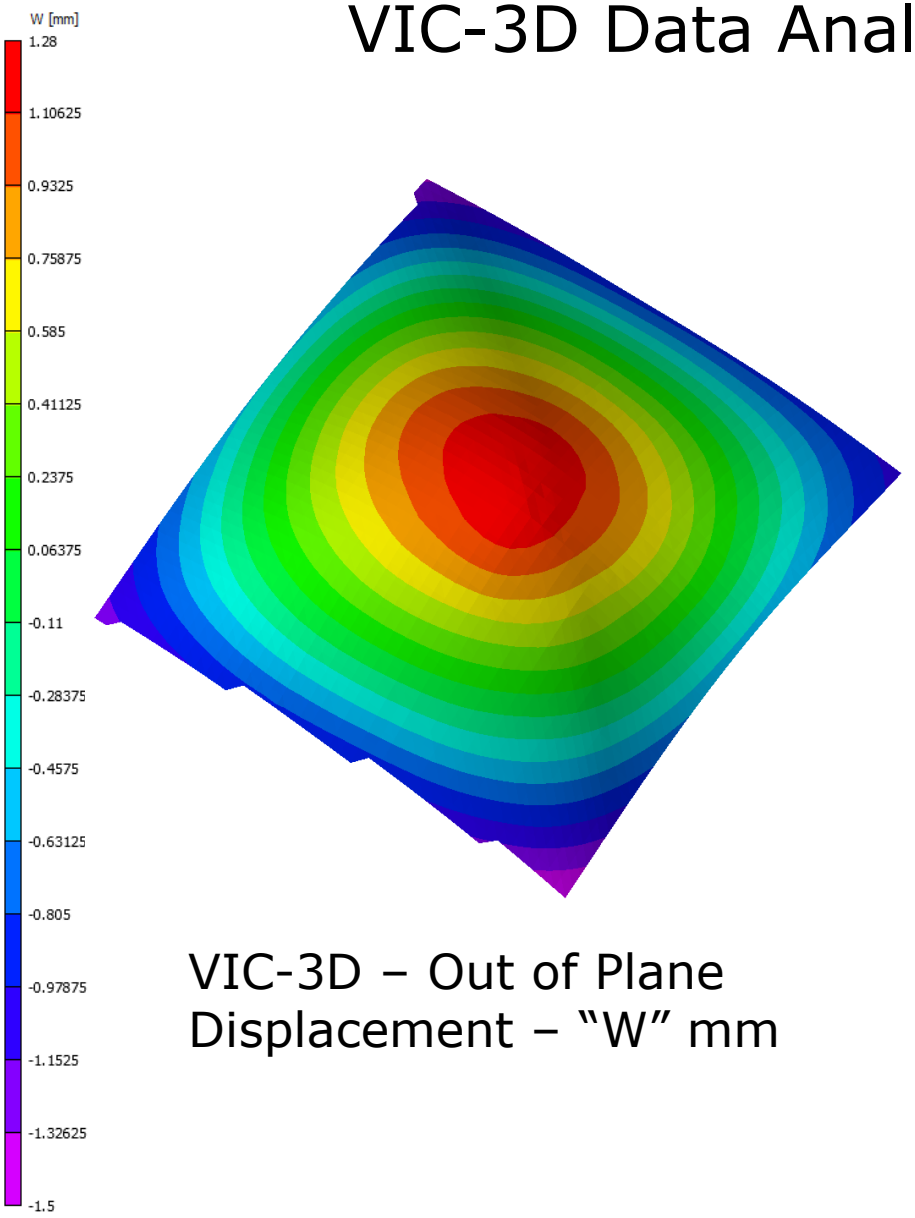
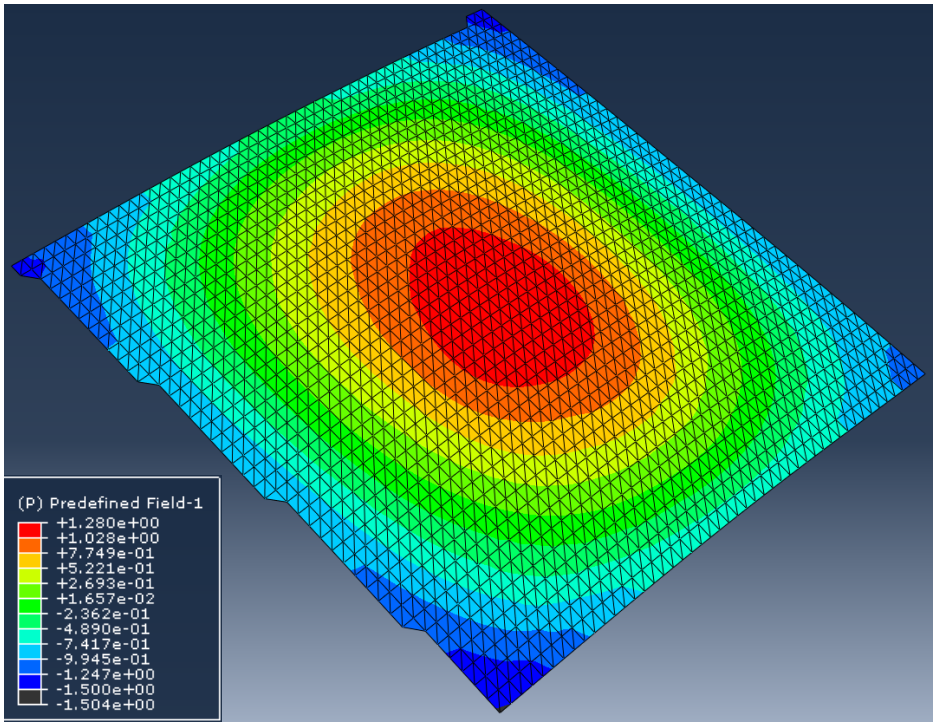
VIC-3D Data Analyzed in FEM - ABAQUS



VIC-3D – Out of Plane Displacement – "W" mm



VIC-3D Data exported and analyzed in ABAQUS

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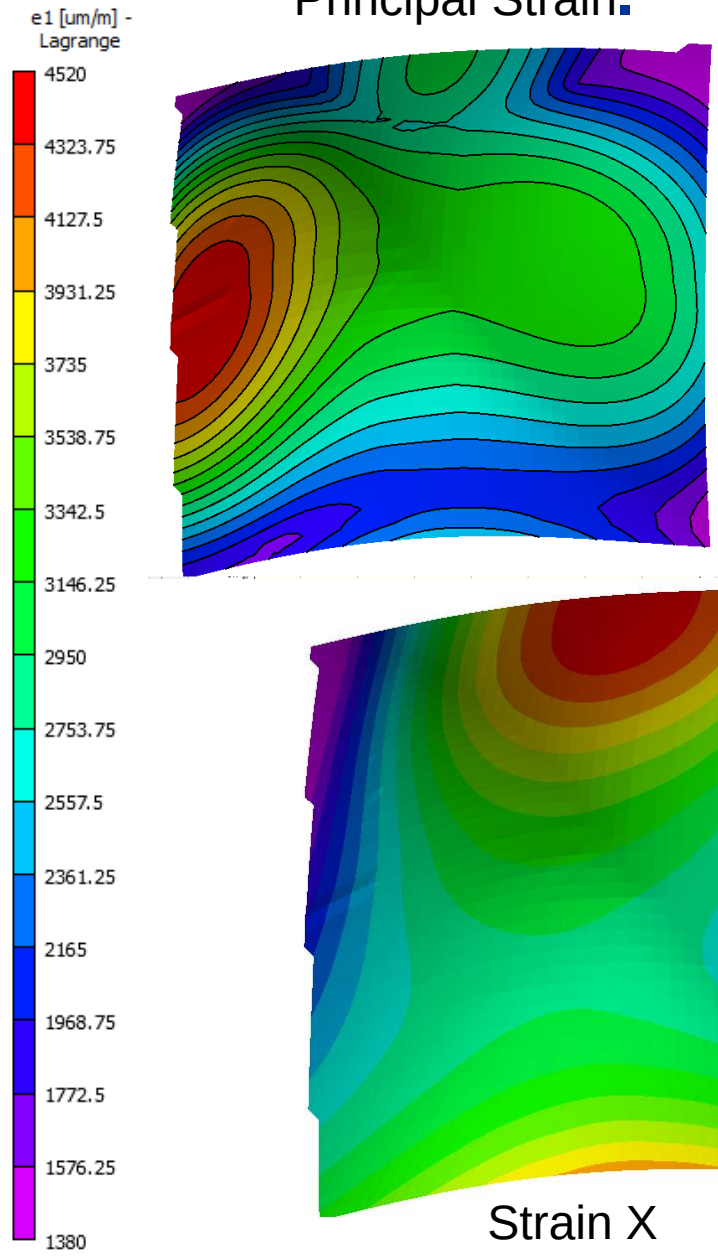
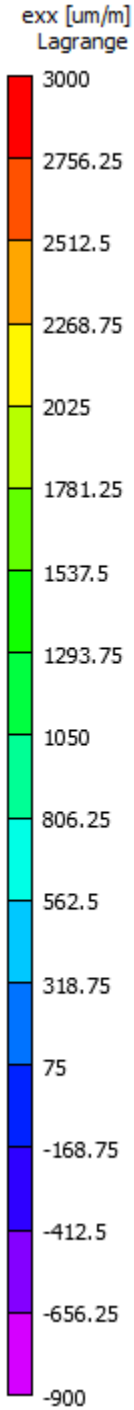
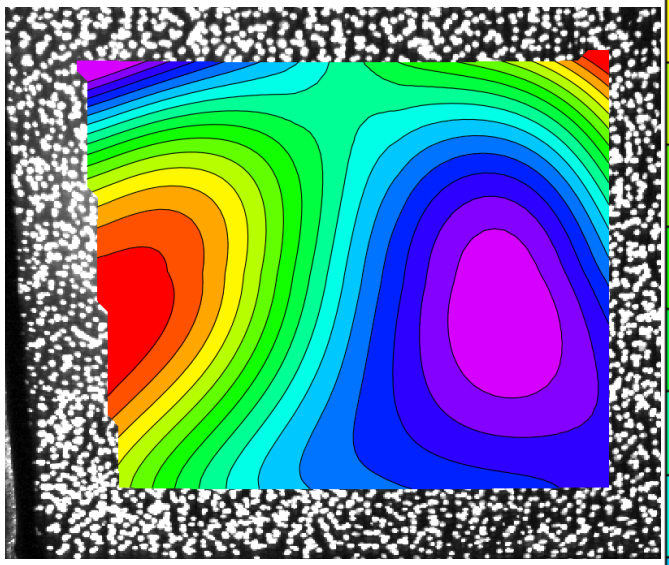
Strain Plots at 0.66 ms.

Principal Strain.

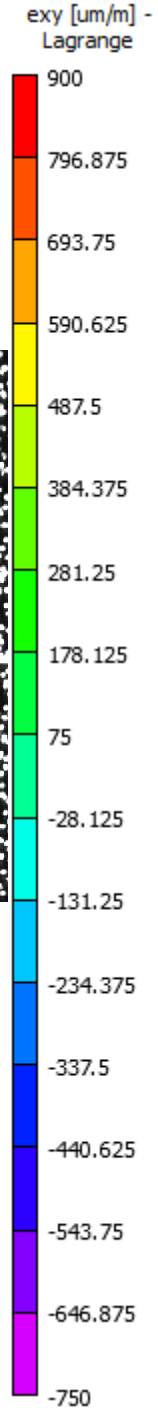


Strain X

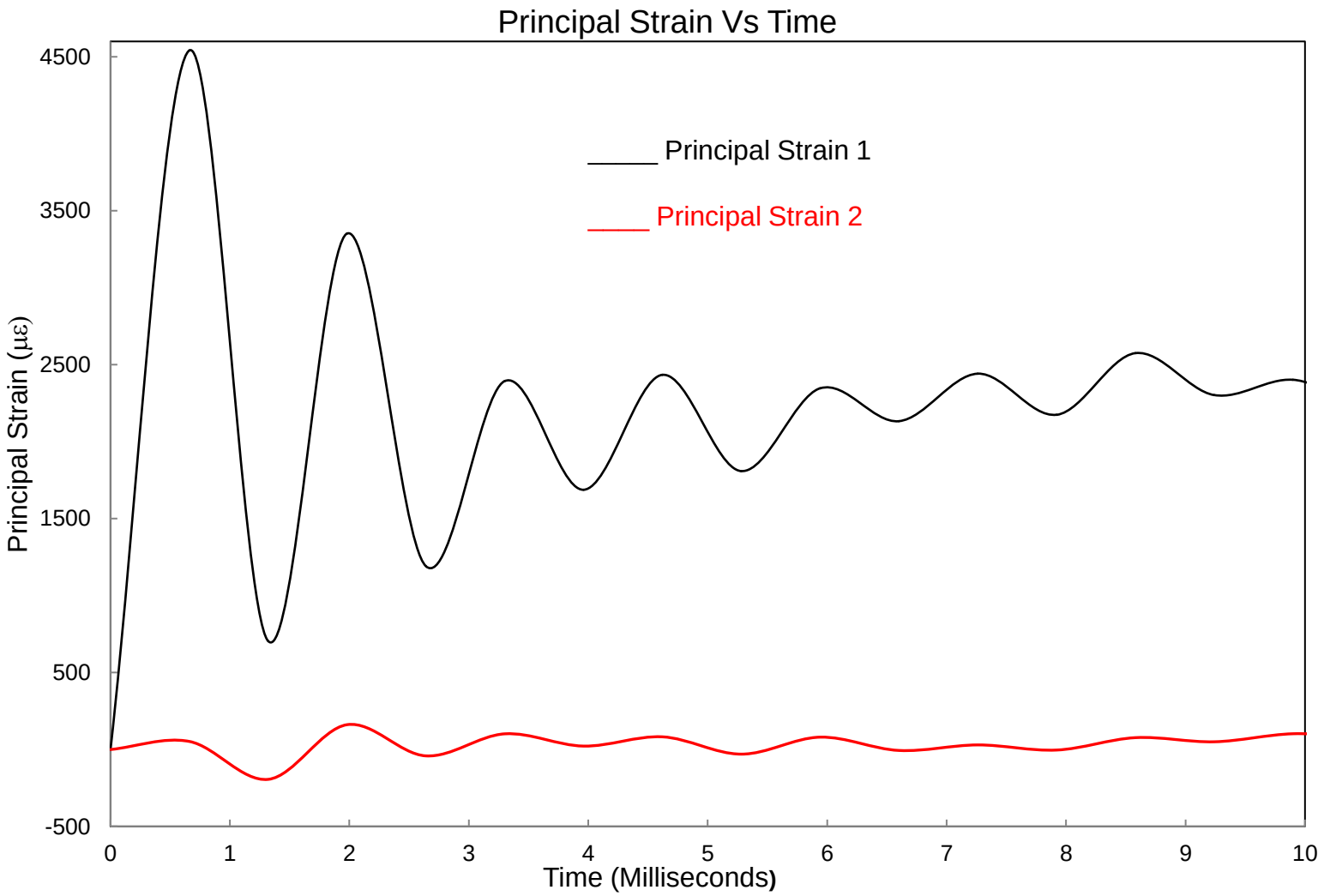




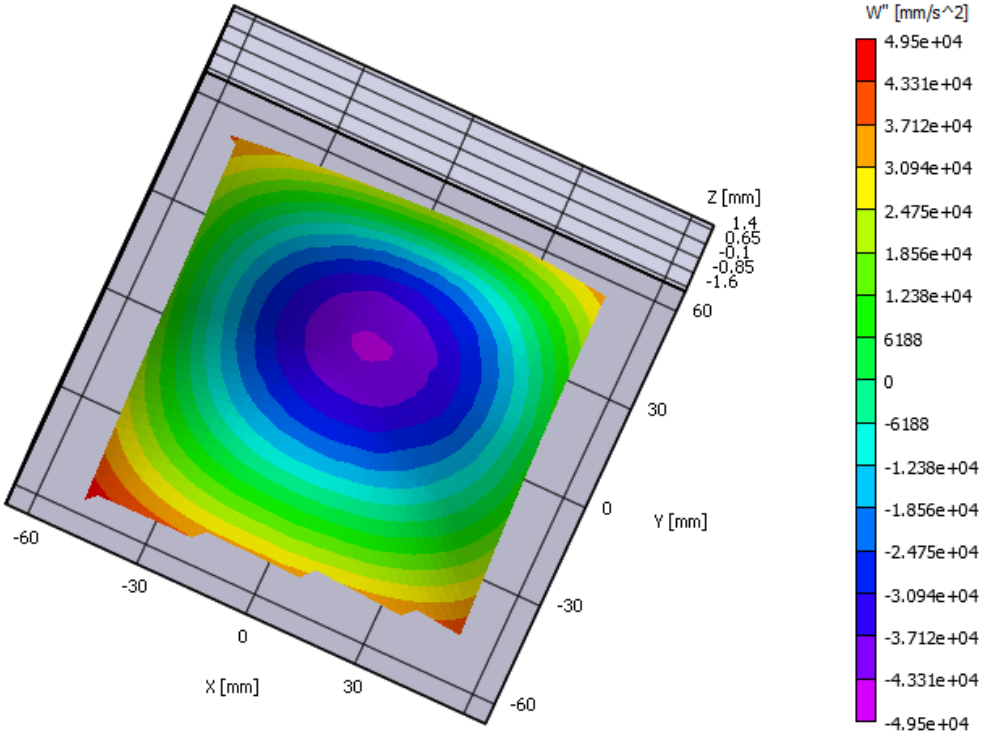
Shear Strain.



PYRO DYNAMICS

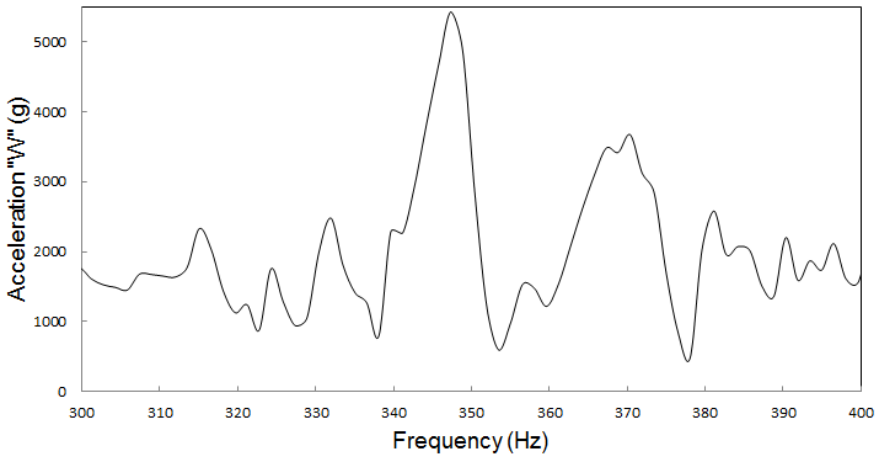


PYRO DYNAMICS



"W" Acceleration
357.531 Hz

FFT Of Acceleration "W"



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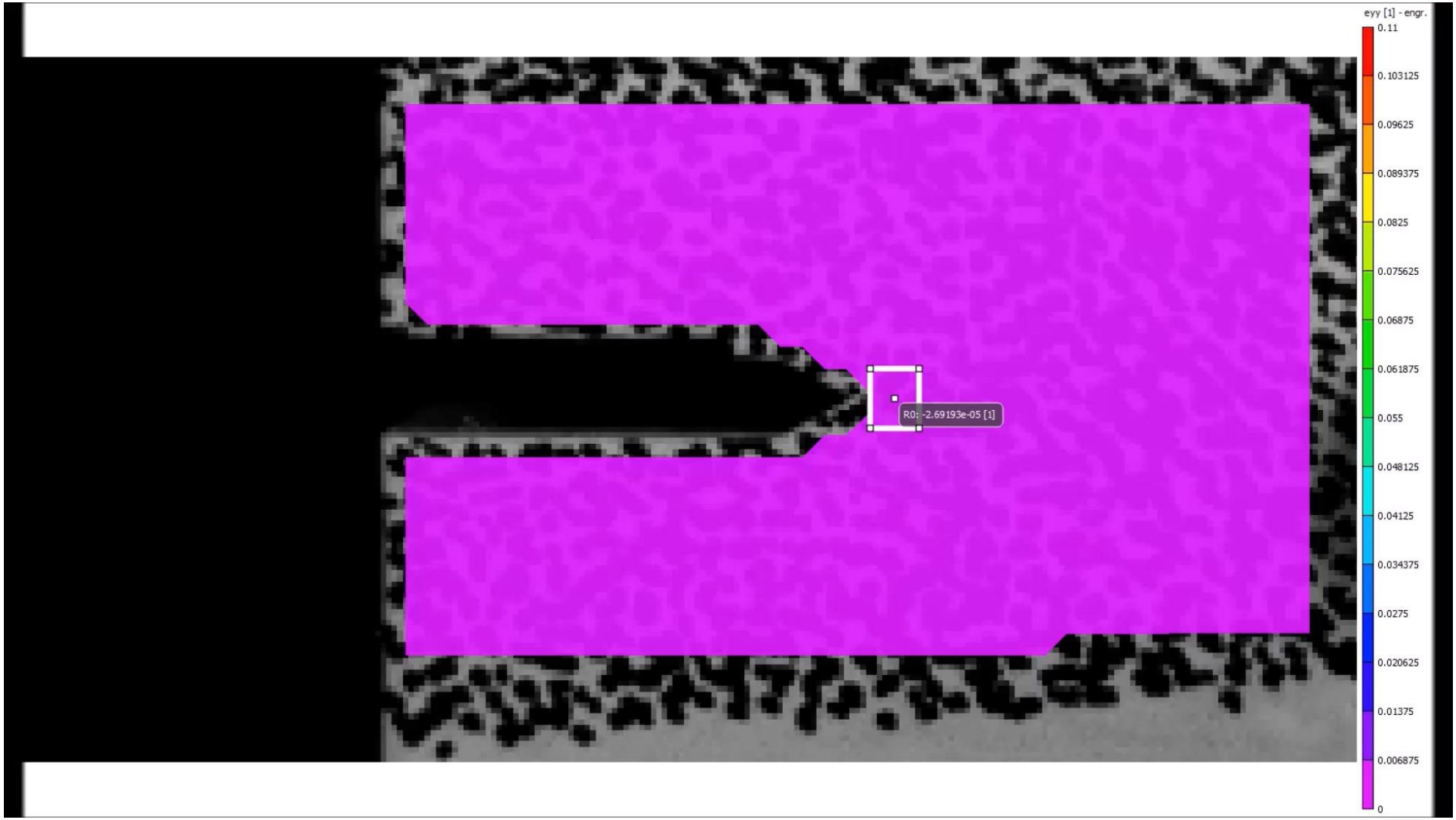
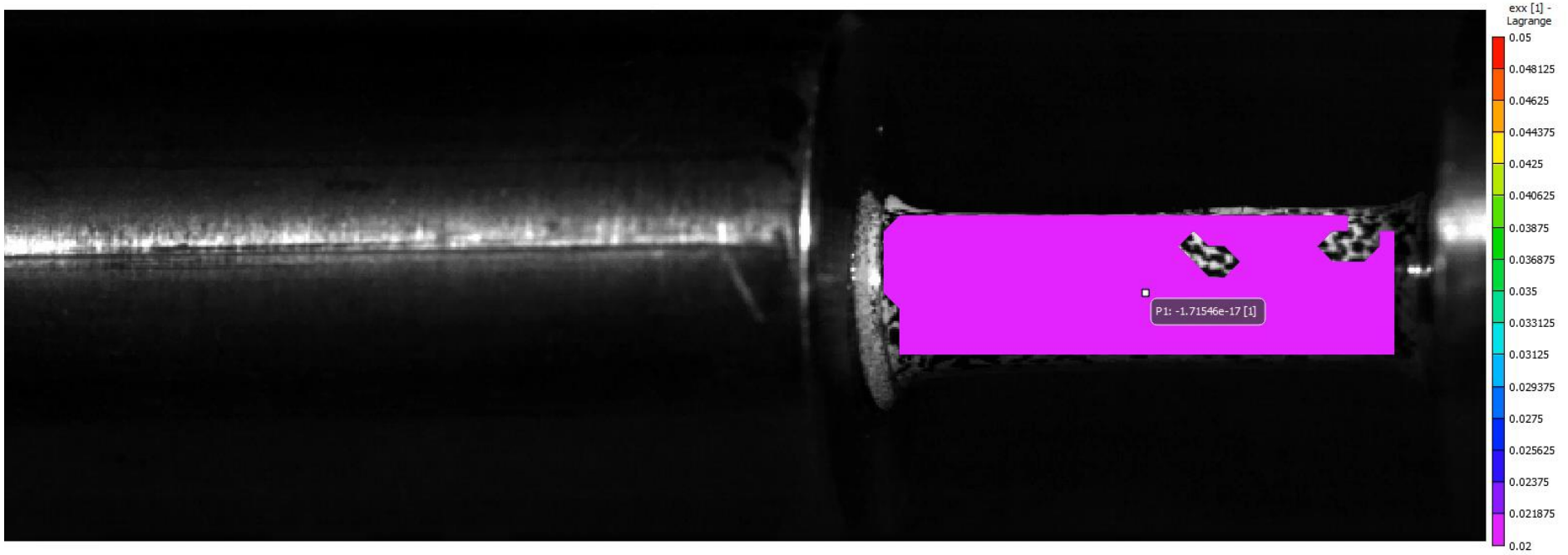
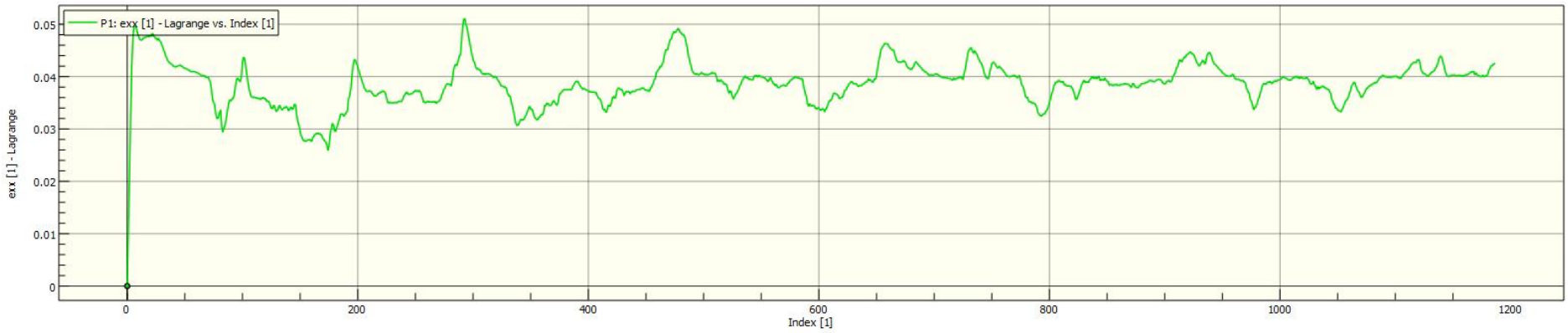
3 Point Bend Test conducted at IIT Delhi using Photron SA-Z Cameras at 135,000 fps



PYRO DYNAMICS

SHPB Test conducted at IIT Delhi using Photron SA-Z Cameras at 135,000 fps





PYRO DYNAMICS

Lets Think Collectively

Thank You

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"A Company of Value Rather than a Company of Success"