THE UNIVERSITY OF TOKYO

RISS RSS21

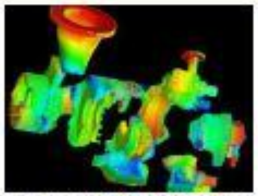
Nonlinear Structural Analysis Open Software

FrontISTR

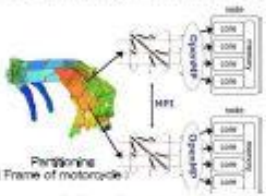
Nonlinear analysis functions are deployed on a parallel FEM basis.
Running on a note PC, PC clusters and supercomputers. FrontISTR provides innovative tools for practical and advanced structural analysis.

Feasibility Studies

Large-scale parallel analysis

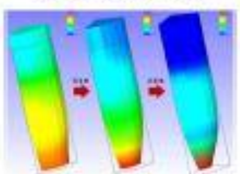


Domain decomposition for parallel computing

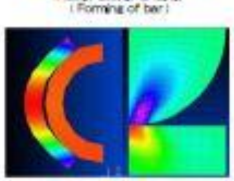


Partitioning
(Frame of motorcycle)

MPI-OpenMP hybrid parallel

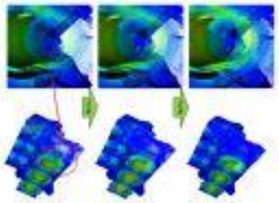


Elastic-plastic analysis
(Forming of bar)

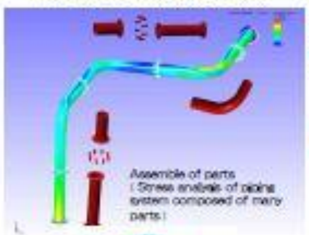


Contact analysis (Contact point transfer, Hertz contact problem)

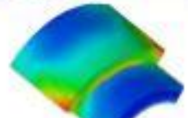
Accurate assembled structure



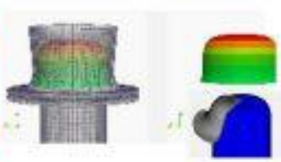
Accurate analysis aided by "Refiner"
(Thermal stress analysis of engine block)



Assemble of parts
(Stress analysis of piping system composed of many parts)

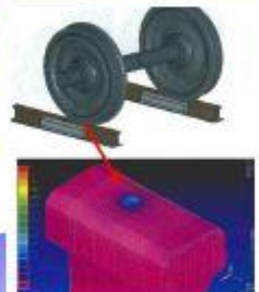


Contact indentation of cylinders

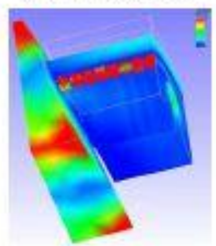


Cupping press simulation

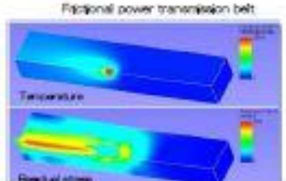
Material & geometrical nonlinear



Rolling contact between fast running train's rail and wheel



Frictional power transmission belt



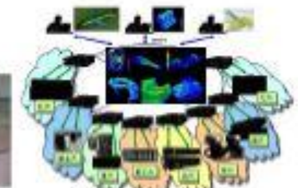
Thermal-elastic-plastic analysis of welding residual stress

Massively parallel, PC cluster, Cloud

Earth Simulator

Win-note cluster

PC cluster



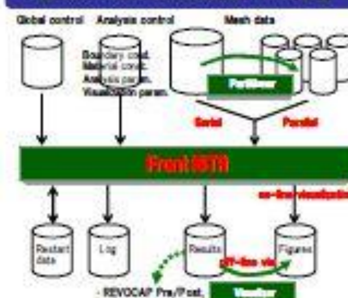
CAE supercomputer cloud

Functions

Function	Supported contents	
Static linear	(Including thermal stress analysis)	
Static nonlinear	Material	Hyper-elasticity/Thermal-Elastic-Plastic/Visco-Elastic/Creep, Combined hardening rule
	Geometry	Total Lagrangian／Updated Lagrangian
	Boundary	Augmented Lagrangian/Lagrangian multiplier method, Finite slip contact, Friction
Dynamic linear	Explicit method / Implicit method	
Dynamic nonlinear	Explicit method / Implicit method	
Eigen value	Lanczos method (considering differential stiffness)	
Heat transfer	Steady / Non-steady (Implicit), Material nonlinear	
Element type	Tetra/Hexa/Prism, Shell, 1st /2nd order, Incompatible mode, SRI	
Utilities	User's subroutine, Restart, Step control of boundary conditions	

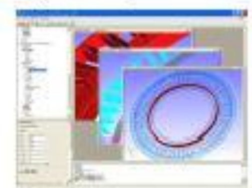
Function	Advanced characteristics
Hierarchical mesh refinement	Analysis of large-scale accurate models with REVOCAP_Refiner
Assembled structure	MPC-preconditioned iterative solver, Finite Slip Contact, Friction
Multigrid method	Convergence acceleration utilizing hierarchical meshes
Enhanced parallelism	Efficient parallel computation using O(10[5]) nodes
Parallel solver	Preconditioned iterative solvers / Parallel direct solver
Parallel visualization	Surface/Volume rendering, on-line visualization
Coupled analysis	Fluid-structure analysis with FrontFlow and REVOCAP_Coupler

Simple procedure for parallel computing



SPMD (Single Program Multiple Data) program performs parallel computations when mesh data is decomposed by the partitioner.

Pre/Post processing



REVOCAP Pre/Post, which is also being developed at the project (*), is available. At the pre-processing stage, IGES data is read, and the input data for FrontISTR is obtained through mesh generation, assembly and BC settings.

An alternative to post-processing, FrontISTR can generate files for AVS and FEMAP.

Screenshot of REVOCAP Pre/Post

Documents / Examples

Installation manual / User's manual / Tutorial guide (currently in Japanese only), 15 examples for various type of analyses.

Platforms

OS : WindowsXP(32bit) / Linux(32bit, 64bit). Executable module is available for Windows.
C compiler : gcc, Intel C　　Fortran compiler : Intel Fortran
Supercomputers : FX10(Univ. of Tokyo), PRIMERGY(Kyushu Univ.), Earth Simulator, Kei, etc.

FrontISTR is supported by the project "Research and Development for Innovative Simulation Software (RISS)". FrontFlow/blue and REVOCAP are a registered trademark of the Center for Research on Innovative Simulation Software (CISS), IIS, the University of Tokyo. All registered trademarks belong to their individual owners.

Please contact us if you would like to use or customize this software.
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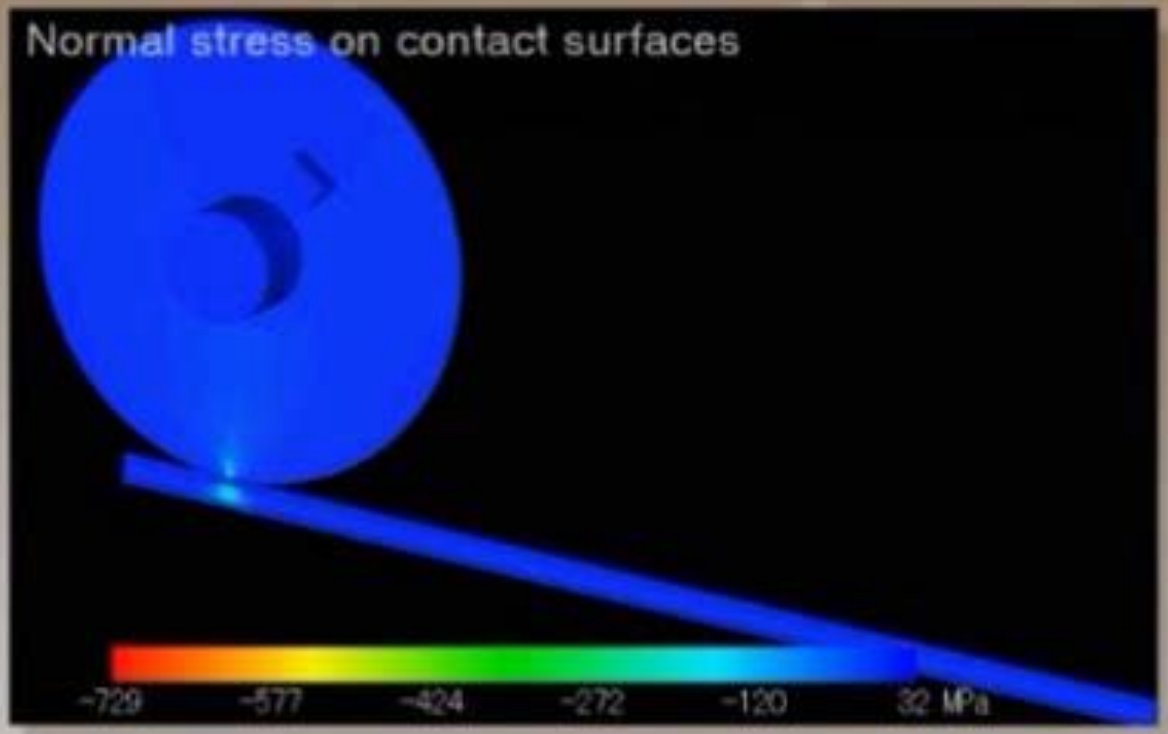
November, 2012

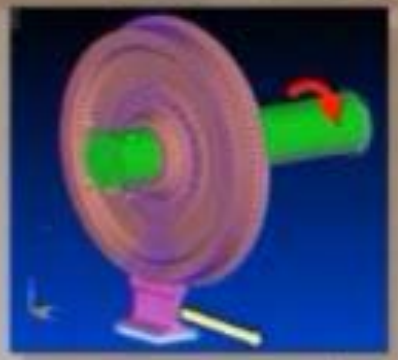
Structural Analysis Functions Supported in FrontISTR

Function	Supported contents	
Static	Material	Elastic/Hyper-elasticity/Thermal-Elastic-Plastic/Visco-Elastic/Creep, Combined hardening rule
	Geometry	Total Lagrangian／Updated Lagrangian
	Boundary	Augmented Lagrangian/Lagrangian multiplier method, Finite slip contact, Friction
Dynamic	Linear/Nonlinear, Explicit/Implicit	
Eigen value	Lanczos method（considering differential stiffness）	
Heat	Steady / Non-steady (implicit), Nonlinear	

Dynamics Rolling Contact Analysis between Rail and Wheel

Joint research with Railway Technical Research Institute



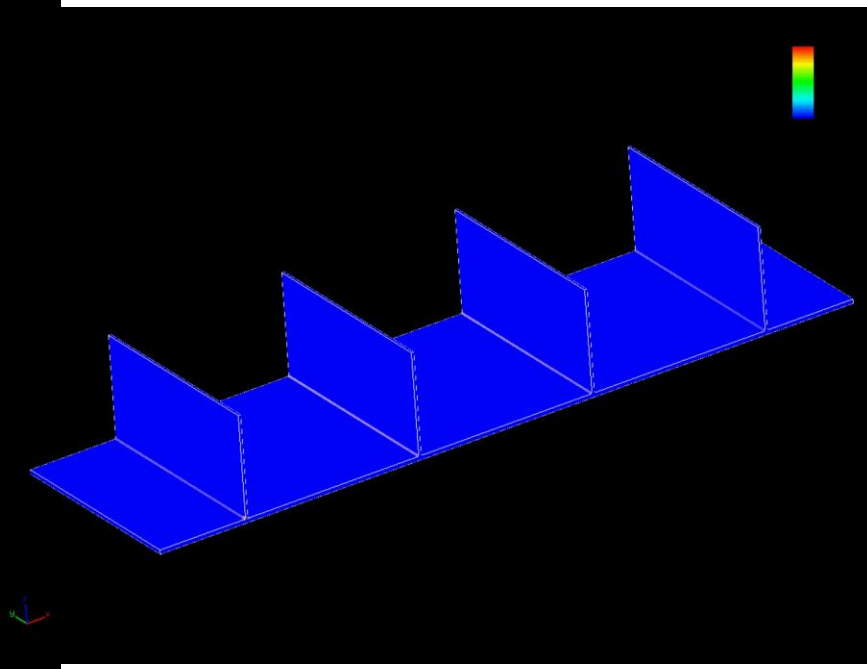


Thermal-Elastic-Plastic Analysis of Welding Residual Stress

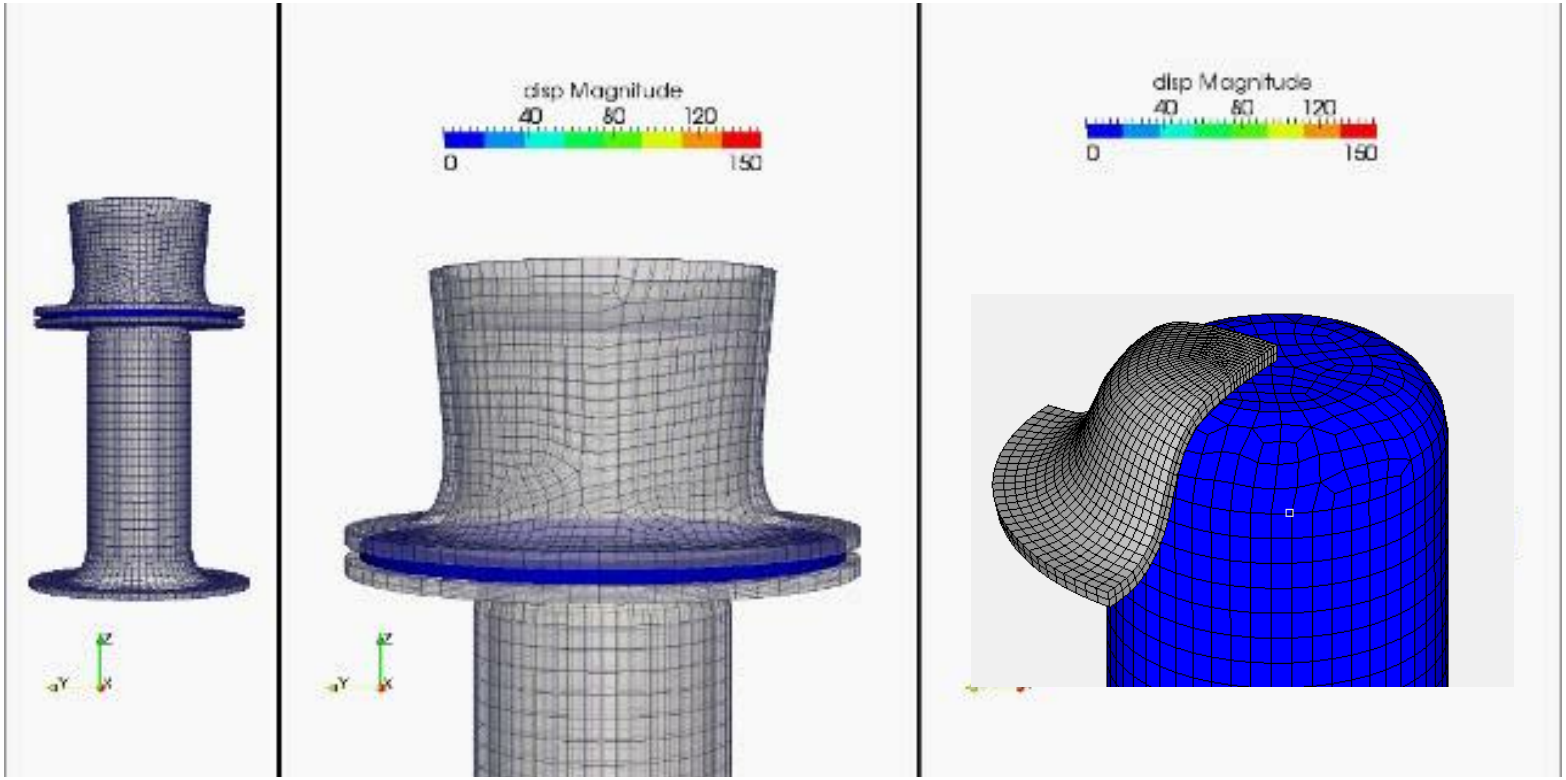
Joint research with IHI

Heat source transfer along a welding line

Residual stress induced by plastic deformation



Cupping press simulation / Elasto-plasticity and friction on contact faces



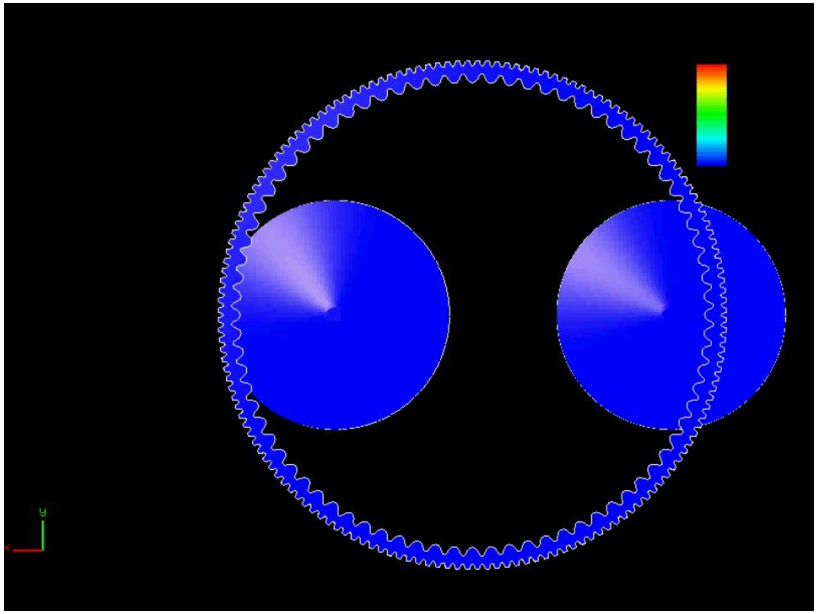
A punch is plugged into a blank, which is placed between a die and a blank holder. The blank is formed into a cylinder shape as the punch is plugged.

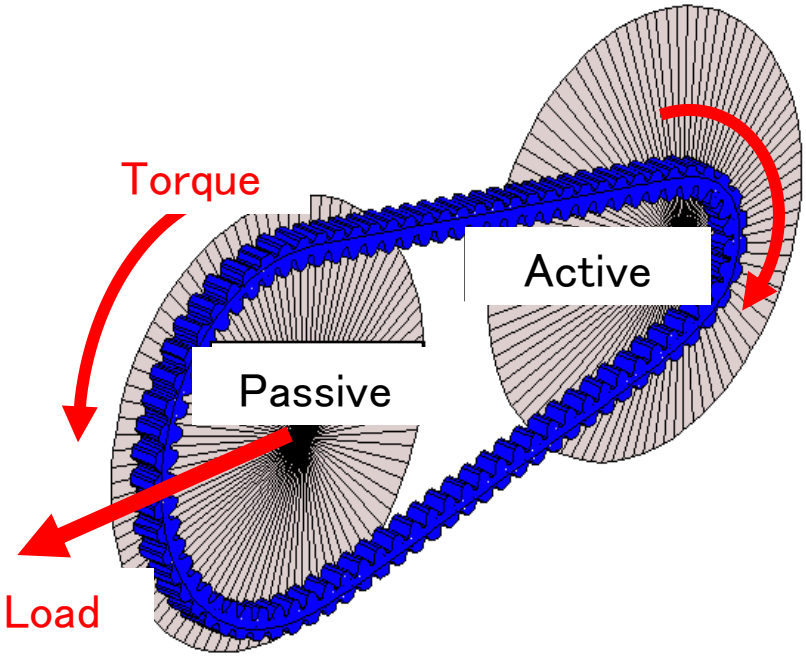
FrontISTR

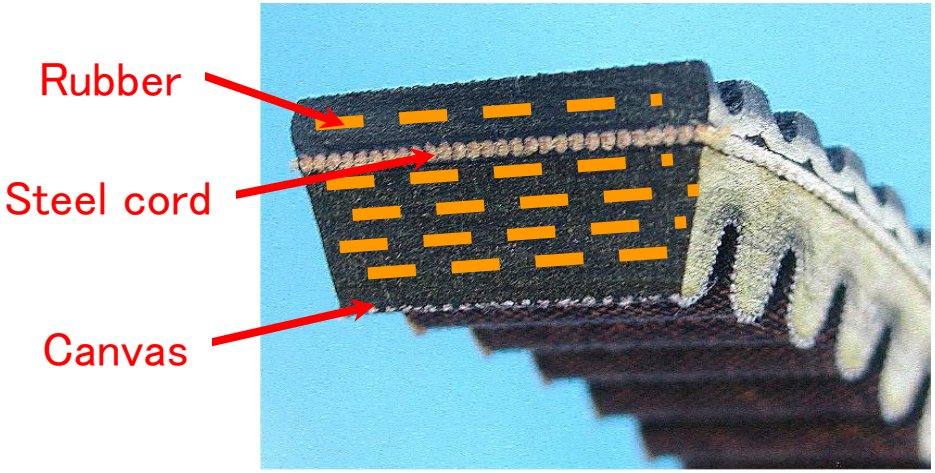
Friction of power transmission belt

Joint research with
Mitsuboshi Belt

V belt



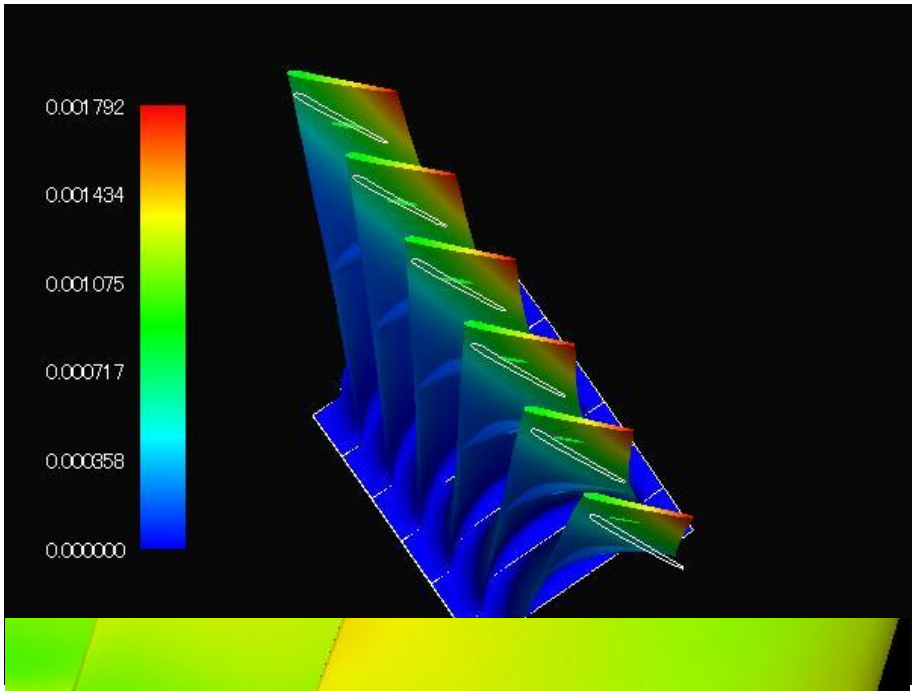


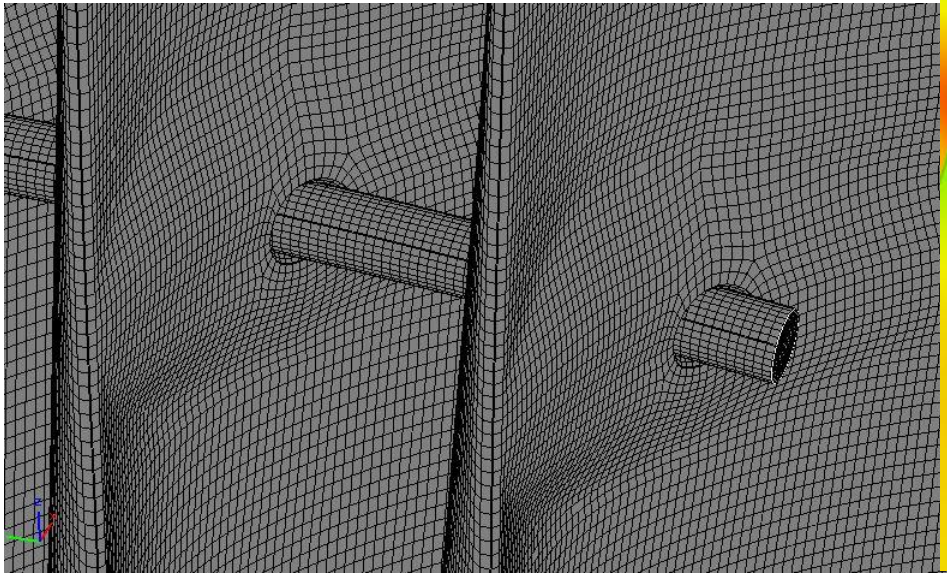


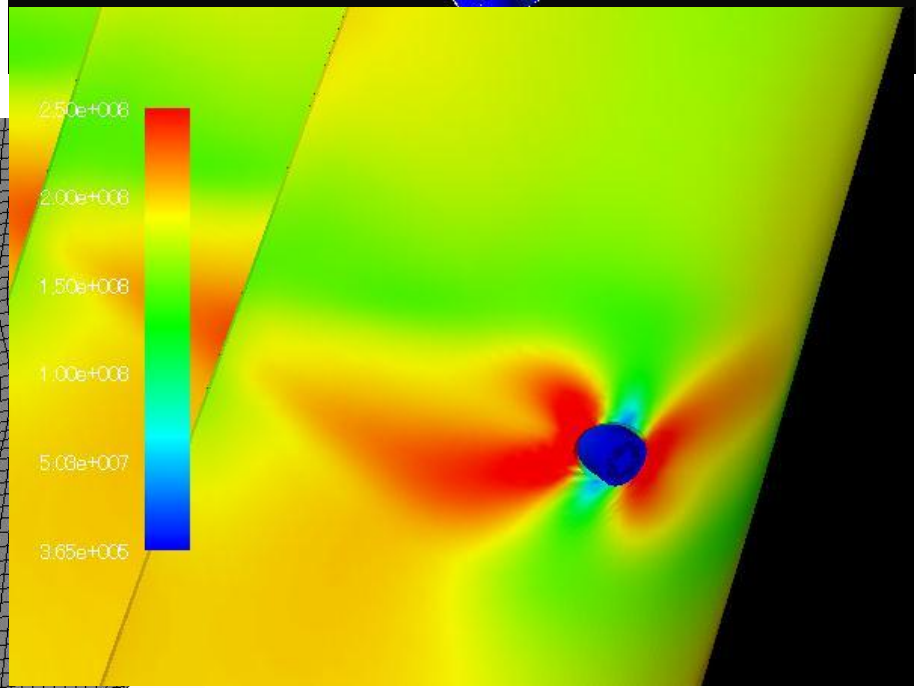
Eigen mode analysis under centrifugal force

Joint research with Toshiba

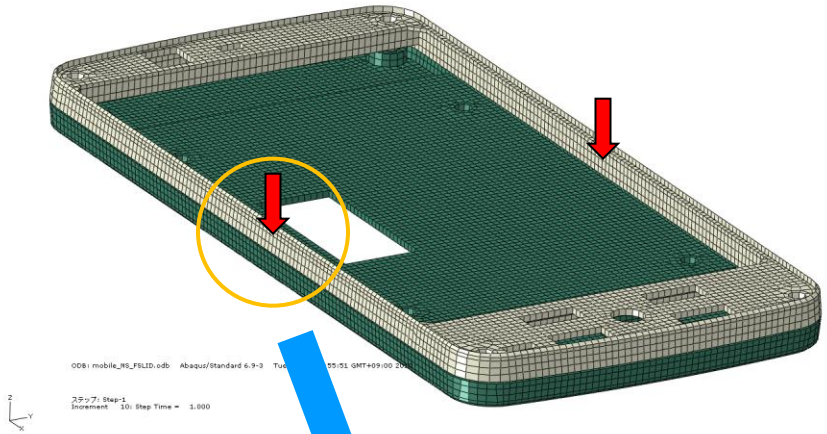
mode1 0.277E+03 mode2 0.466E+03

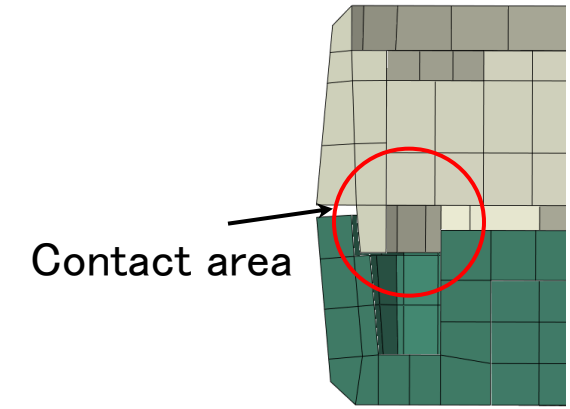


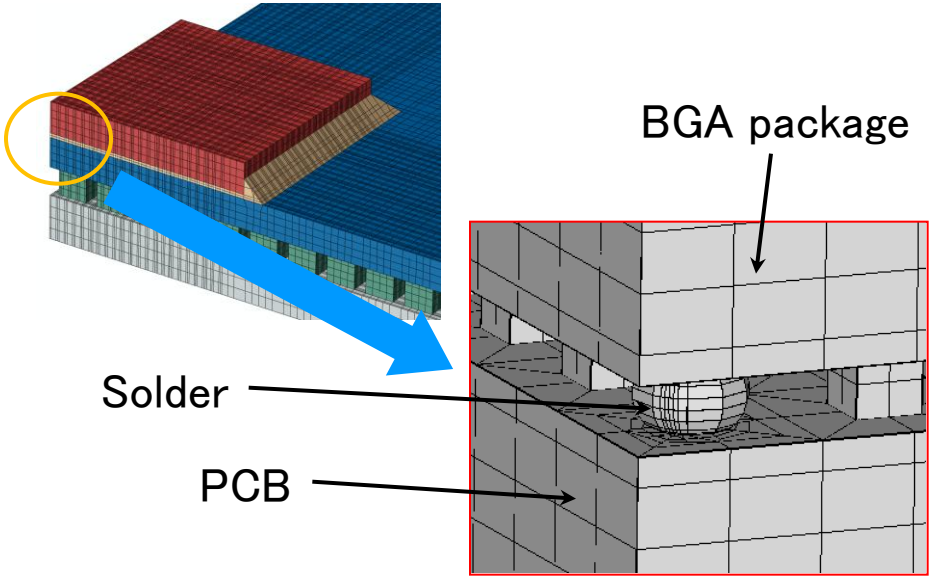




Structural integrity analysis of electrical devices



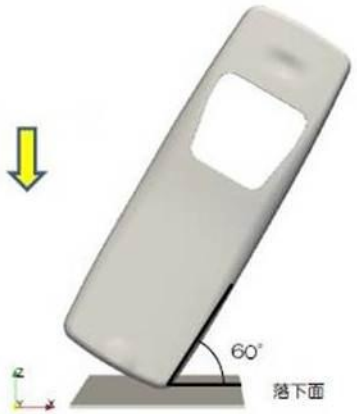


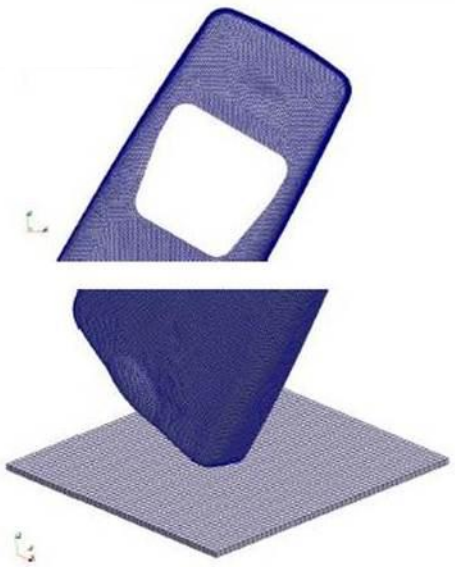


Mises stress

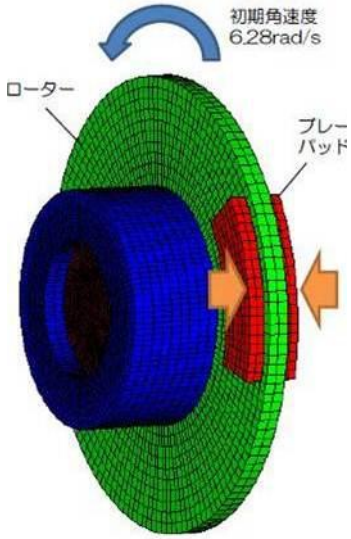
courtesy of ASTOM

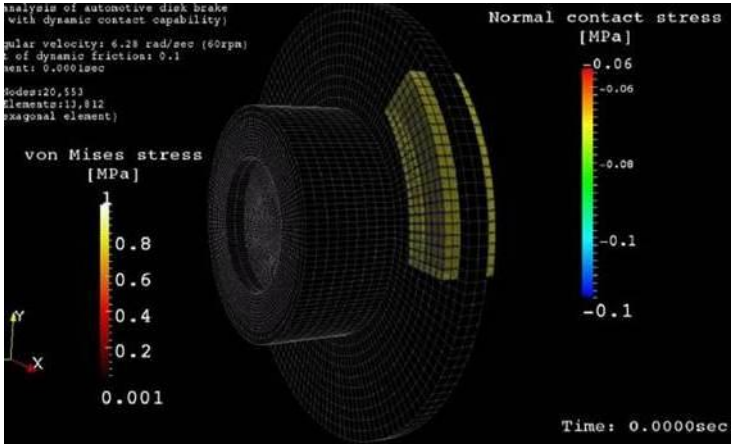
Structural integrity analysis of electrical devices

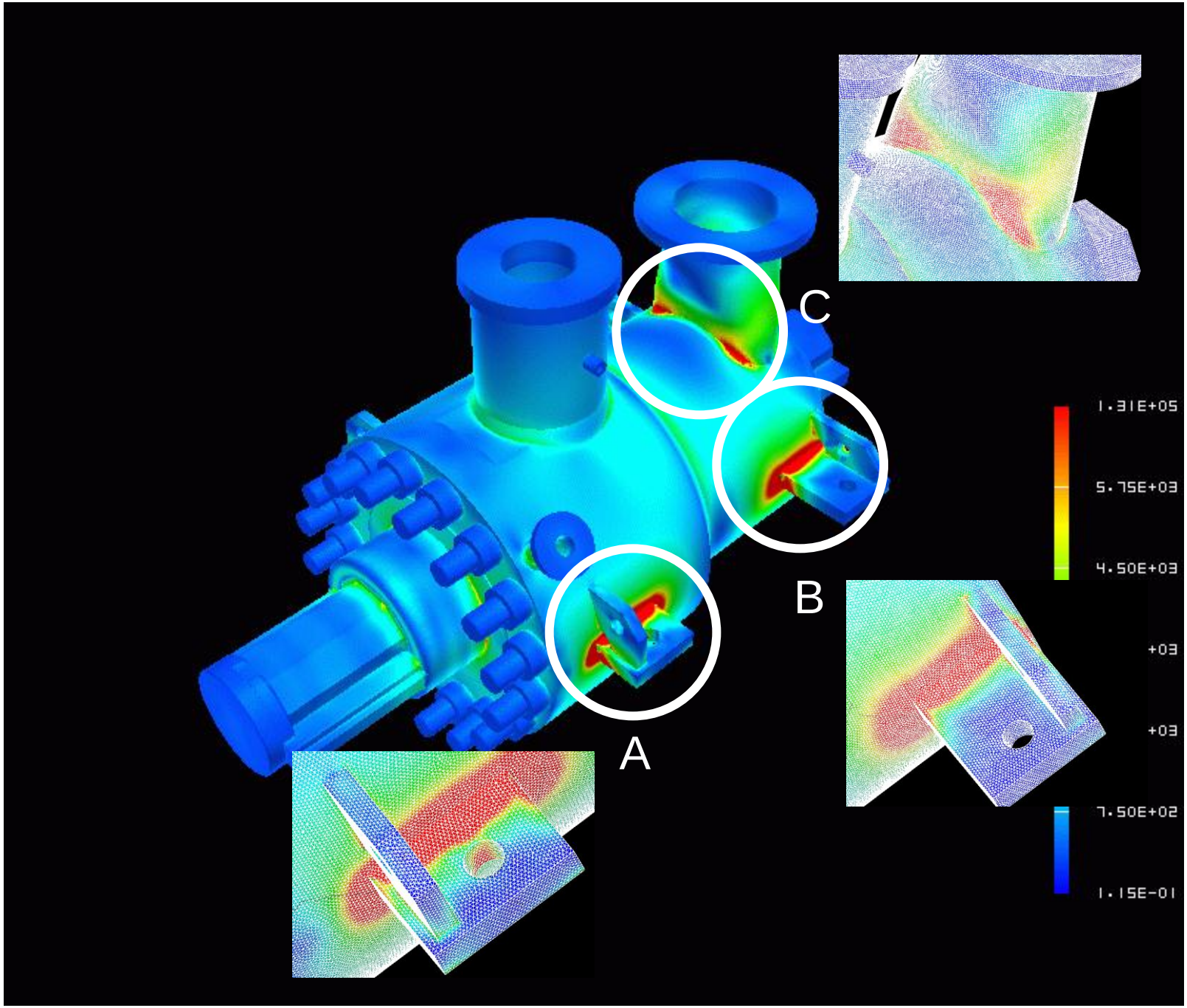


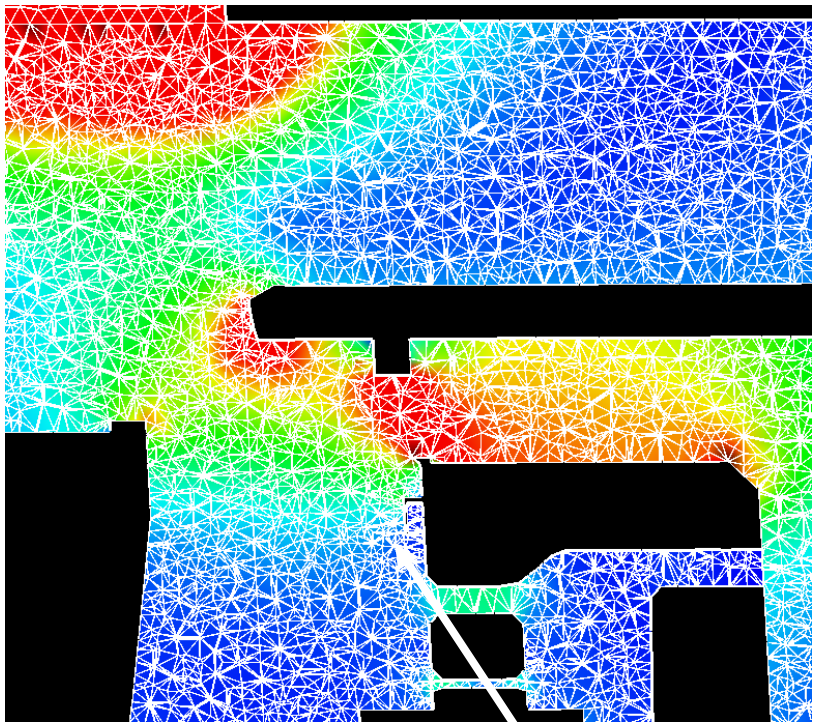


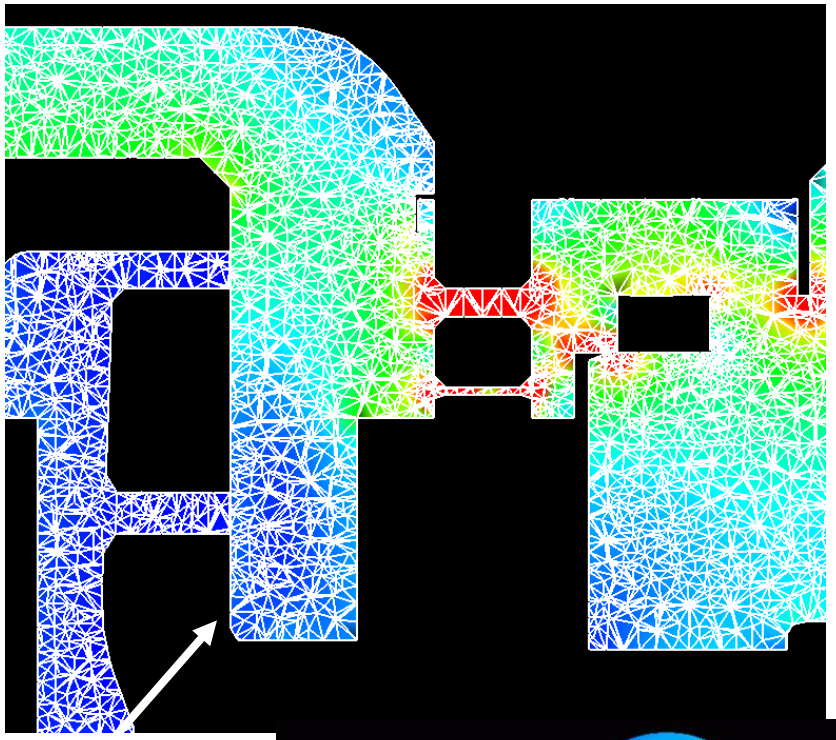
Contact force analysis of brake disk

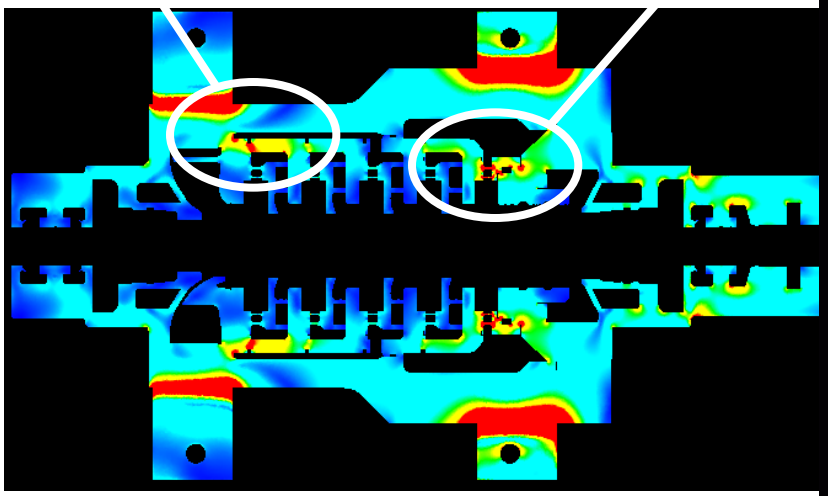


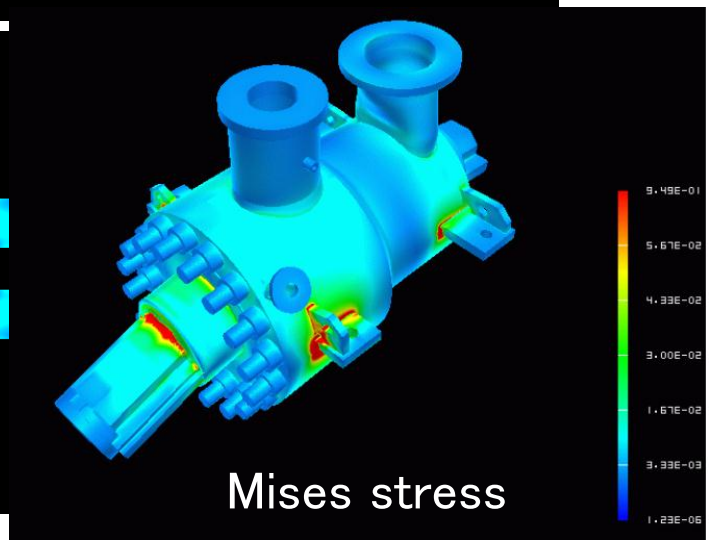



C
B
A
1.31E+05
5.75E+03
4.50E+03
+03
+03
7.50E+02
1.15E-01



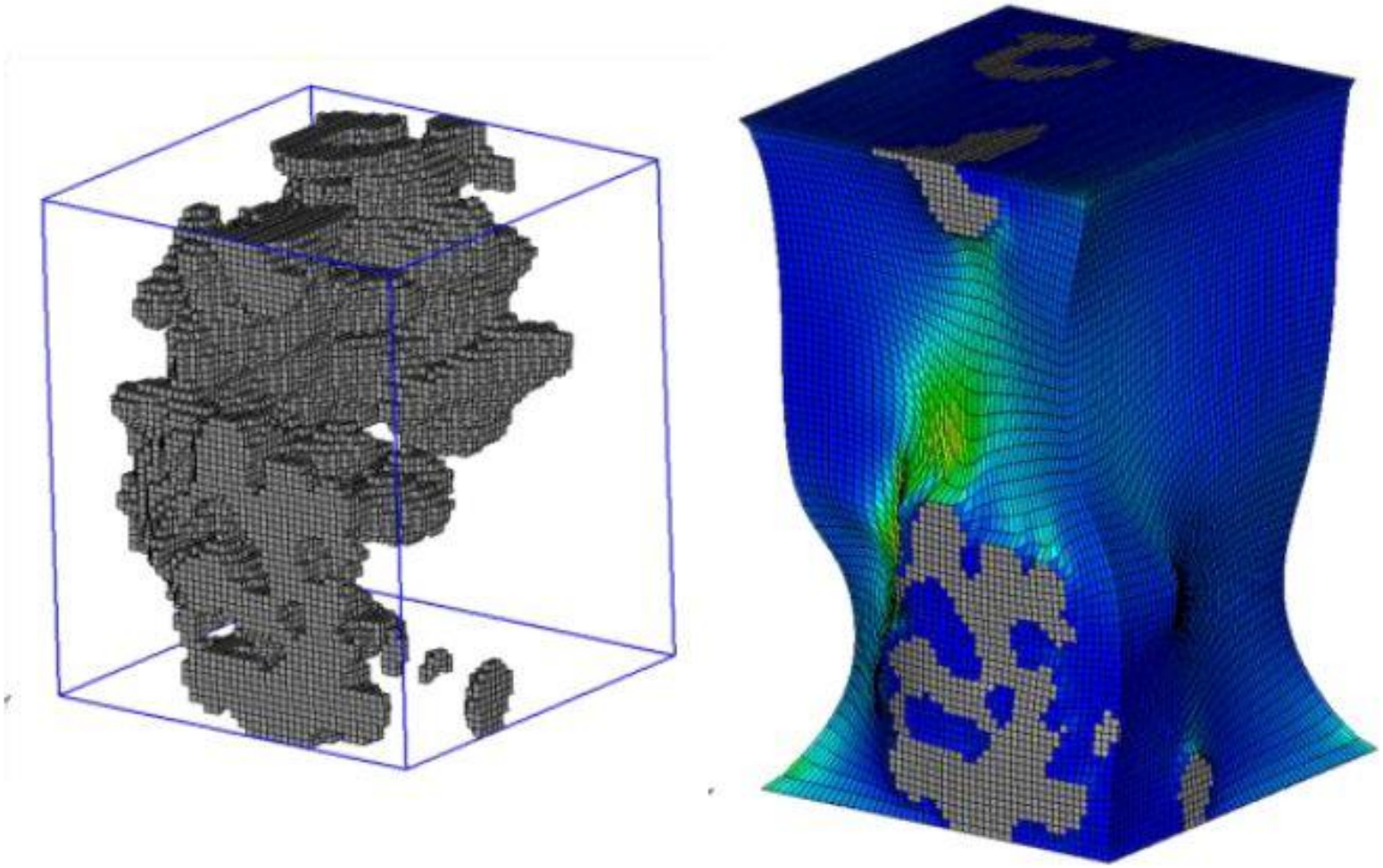





9.49E-01
5.67E-02
4.33E-02
3.00E-02
1.67E-02
3.33E-03
1.23E-06
Mises stress

Large Strain Analysis of Rubber with Fillers

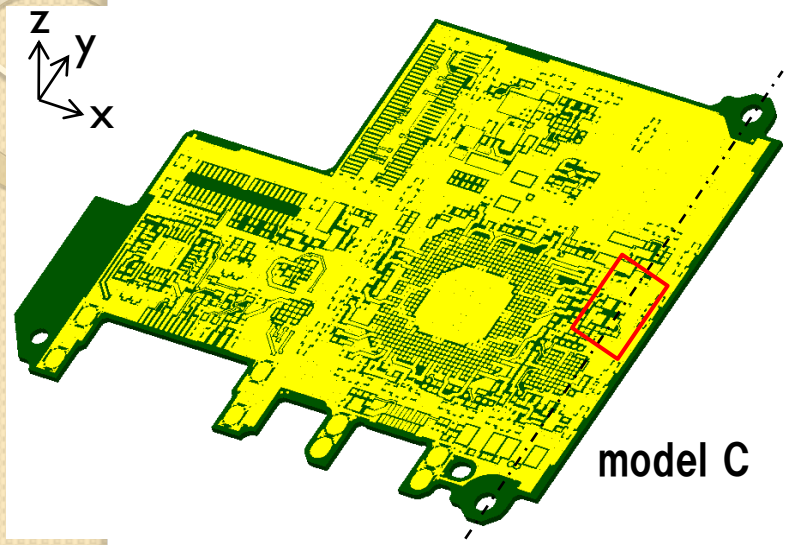
Joint research with Bridgestone



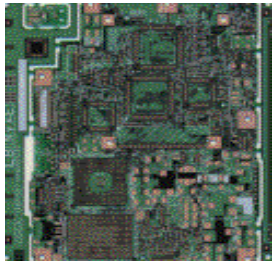
HPCI program for industrial use on K

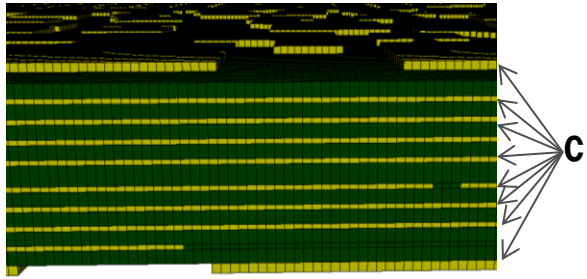
Joint research with Fujitsu

Model for Warp of PCB



model C





circuit layer

cross section（10 layer PCB）

-Temperature condition : 25℃ → 240℃

-Type of mesh : 3D solid（ hexahedra ）

Model size

	mesh size (μm)	nodes	Elements
model A	500	136,880	124,714
model B	100	3,272,252	3,046,839
model C	30	41,044,244	38,689,706

Material constants（ for linear analysis ）

	Young’s modulus (MPa)	Poisson’s ratio	CTE (1/℃)
DI	4639	0.49	1.47E-05
Paste	4600	0.343	2.77E-05
Cu	65457	0.343	1.63E-05

DI : dielectric（resin）

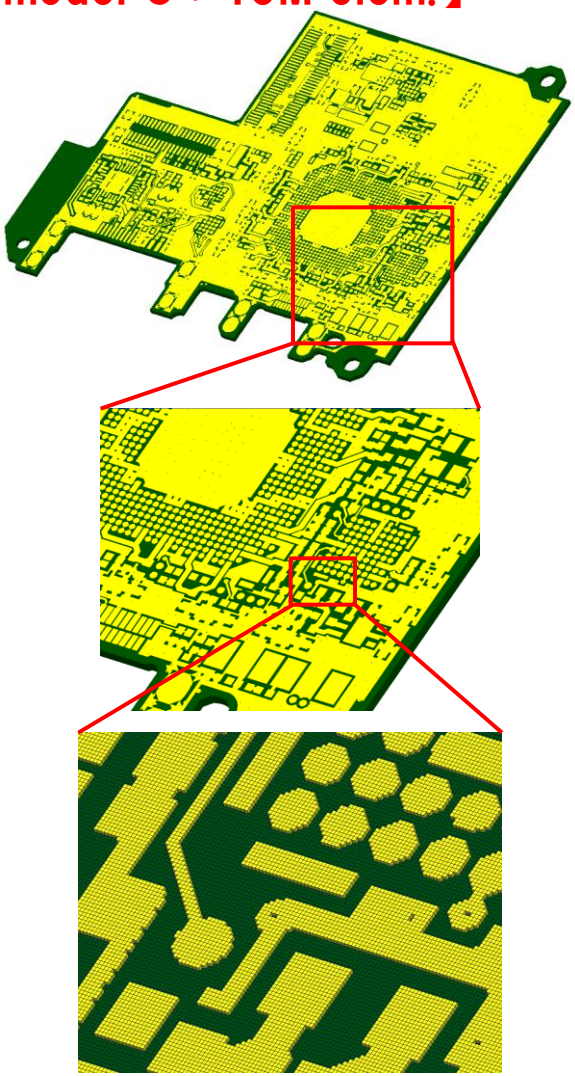
【model A : 0.1M elem.】

mesh size：500μm

【model B : 3M elem. 】

mesh size：100μm

【model C : 40M elem.】

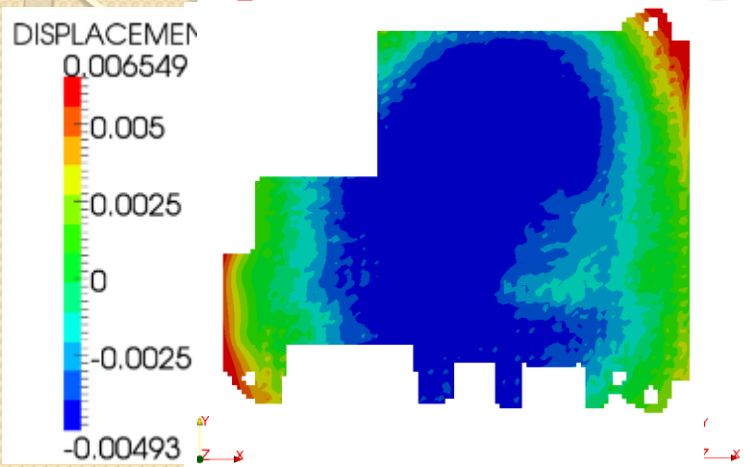


mesh size：30μm

coarse → fine

◆Results of linear analysis : displacements in z-direction

【model A : 0.1M elem.】

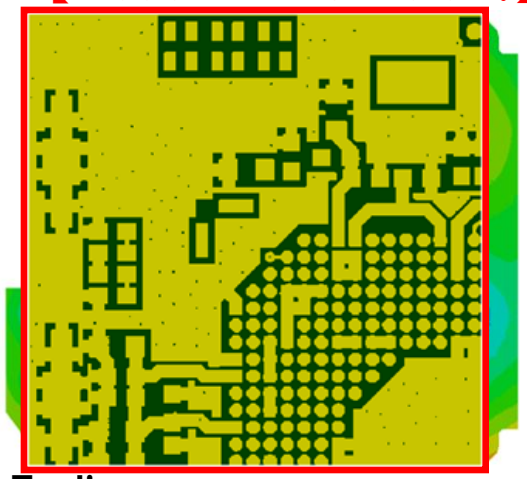


Z-disp.
plus : 0.00896 mm
minus : -0.0119 mm

【model B : 3M elem. 】

Z-disp.
plus : 0.00782 mm
minus : -0.00251 mm

【model C : 40M elem.】



Z-disp.
plus : 0.00655 mm
minus : -0.00493 mm

【model C】

- CPU time : 3.69 h (1,024PEs of FX10@UT)
- CG itrs. : 0.4 M iterations

Material non-linear analysis

- Temperature dependent material properties
- Viscoelasticity for DI

・Temperature：25℃⇒245℃
・Simulation time ：600sec

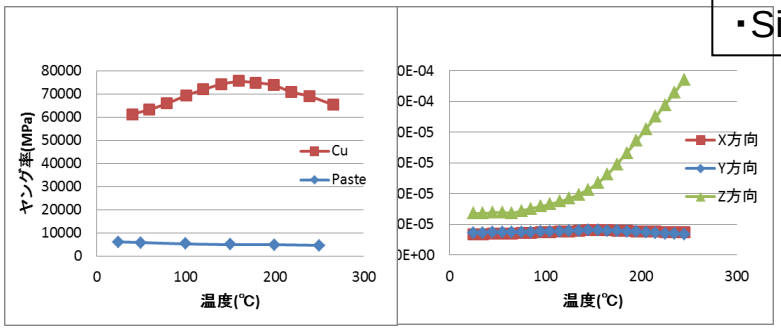
材料名	ヤング率(MPa)	ポアソン比	線膨張係数(1/℃)
DI	20519	0.3	図2
Paste	図1	0.343	2.77E-05
Cu			1.63E-04

粘弾性特性：Prony係数

材料名	g	k	t
DI	4.08E-02	0	1.02E-11

粘弾性特性：WLF式

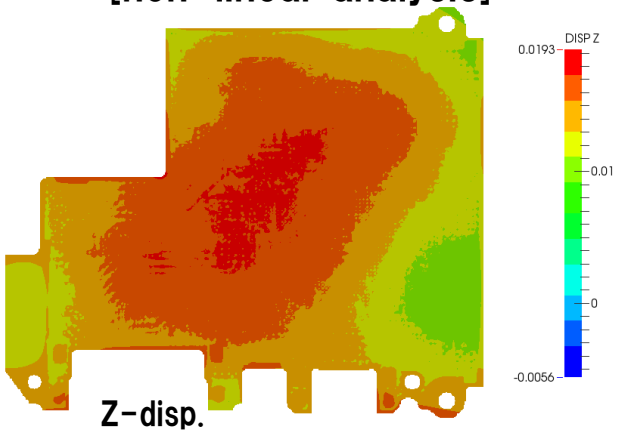
材料名	θ ₀	C1	C2
DI	150	58	620



Young's modulus of Cu and Paste　　CTE of DT

【model B : 3M elem. 】

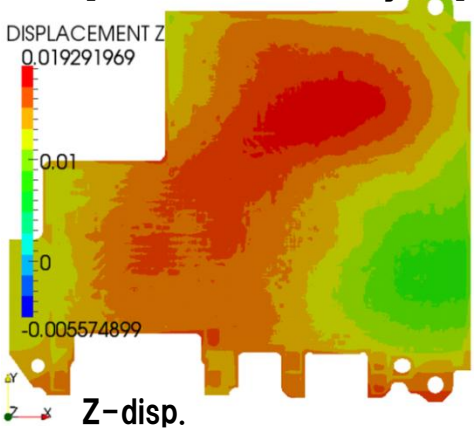
[non-linear analysis]



Z-disp.
plus　：　0.01854 mm
minus ：-0.00440 mm

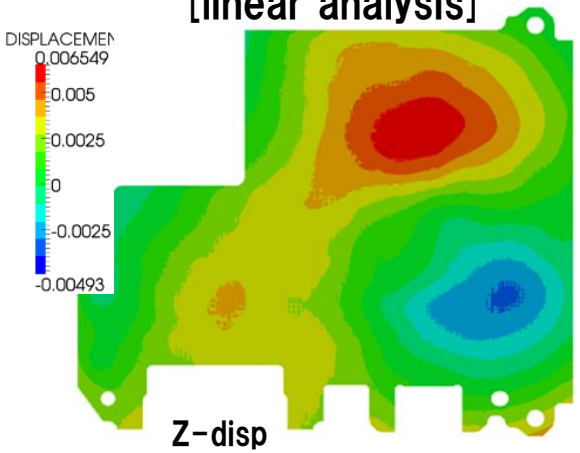
【model C : 40M elem.】

[non-linear analysis]



Z-disp.
plus　：　0.01929 mm
minus ：-0.00560 mm

[linear analysis]



Z-disp
plus　：　0.00655 mm
minus ：-0.00493 mm