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Example use case for ExoToComsol converter software

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ExoToComsol is a converter software written in Python providing two-way conversion capability between SIERRA[1] and COMSOL FE file formats. The file format used in SIERRA FE code is EXODUS II [2], and hence a short name of the converter program is ExoToComsol. The converter program allows FE data (mesh and simulation data) from one FE code (SIERRA/COMSOL) to be imported into another so that a subsequent physics simulation can be performed using FE data from the first simulation. This is useful in modeling capability sharing, for example, developing a Multiphysics modeling chain using physics modeling capabilities developed by different research institutions using either SIERRA or COMSOL. The converter program also allows export of a user-defined region-of-interest (ROI) from a large FE model so that if desired a finer mesh of the submodel can be developed and used for subsequent analysis. Below, we show how the converter program can be used for this purpose.

A large FE model of a silicon solar cell containing 5 million TET elements is used first to simulate the thermal cool-down process of interconnect soldering onto a silicon wafer. SIERRA's thermal modeling code ARIA is used to perform the heat-transfer simulation to solve for temperature profile (Figure 1). The FE result generated by SIERRA is written in Exodus II format. The converter program takes the Exodus II result file along with user's region-of-interest (ROI) information and outputs a file containing both mesh and simulation result data for ROI which can be directly imported into COMSOL to perform additional simulation. For example, in Figure 1, the result of a solid mechanics simulation in COMSOL is shown using the imported temperature field for SIERRA demonstrating contraction of wafer as it cools down during the soldering. A second example is shown where a finer mesh in generated in COMSOL to be used with the imported temperature field from SIERRA for solid mechanics simulation in COMSOL.

Following steps are used to run the above example use case:

a. Run the 'result_Aria_solder_cooling_TET.e' EXODUS file with the ExoToComsol program with the following ROI to generate the COMSOL files for first- and last-time steps

   ROI: x_coord_lower_bound = 0.059, x_coord_upper_bound = 0.060 (59 mm to 60 mm); y_coord_lower_bound = 0.00230, y_coord_upper_bound = 0.00250 (entire wafer thickness), z_coord_lower_bound = 0.059, z_coord_upper_bound = 0.060 (59 mm to 60 mm)

   This step generates two files for import into COMSOL: 'forComsolInput_Aria_solder_cooling_TET_first_time_step_roi_cropped.txt' and 'forComsolInput_Aria_solder_cooling_TET_last_time_step_roi_cropped.txt'

b. Import the ExoToComsol program generated txt files as interpolation functions in COMSOL and use them for temperature definitions for Solidmechanics Physics in COMSOL

c. Import the ExoToComsol program generated txt files as mesh in COMSOL. For mesh refinement, first generate geometry from mesh and then mesh the new geometry with desired mesh resolution.

d. Provide boundary conditions for the ROI model. In above example use case, roller supports were provided on x- and z- surfaces and a corner node at the top of wafer was fixed.

e. Compute for Solidmechanics physics in COMSOL

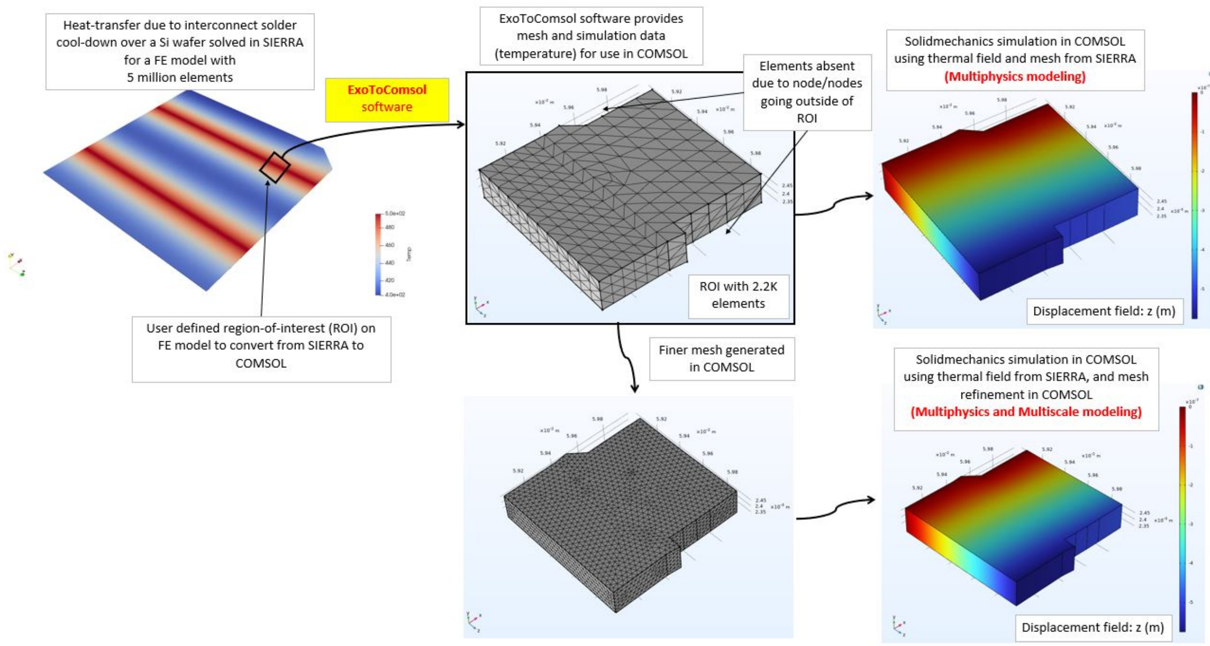

Figure 1: Multiphysics and Multiscale modeling across FE codes using ExoToComsol program

Addendum

result_Aria_solder_cooling_TET.e has file size of 2.7 GB while DuraMAT's Data Hub (https://datahub.duramat.org) allows maximum file size of 2 GB. Therefore, result_Aria_solder_cooling_TET.e is decomposed into smaller files which are posted into DuraMAT's Data Hub. To retrieve result_Aria_solder_cooling_TET.e following steps are required:

a. Install opensource SEACAS module (https://github.com/sandialabs/seacas). Installation instruction for SEACAS can be found in the provided link.
b. Run 'epu --auto result_Aria_solder_cooling_TET.e.*' which will generate result_Aria_solder_cooling_TET.e

References

[1] M. T. Merewether et al. Sierra/SolidMechanics 4.56 User's Guide. United States: N. p., 2020. Web. doi:10.2172/1608404.

[2] Schoof, Larry A. and Yarberry, Victor R., “EXODUS II: A Finite Element Data Model” Sandia National Laboratories, Computational Mechanics and Visualization Department, September, 1994.

Acknowledgements

Funding was provided as part of the Durable Module Materials Consortium (DuraMAT), an Energy Materials Network Consortium funded by the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Solar Energy Technologies Office.

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy’s National Nuclear Security Administration under contract DE-NA0003525.