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Thermal Cycling Induced Residual Stress in Dissimilar Materials Studied using FEM Multiphysics Models

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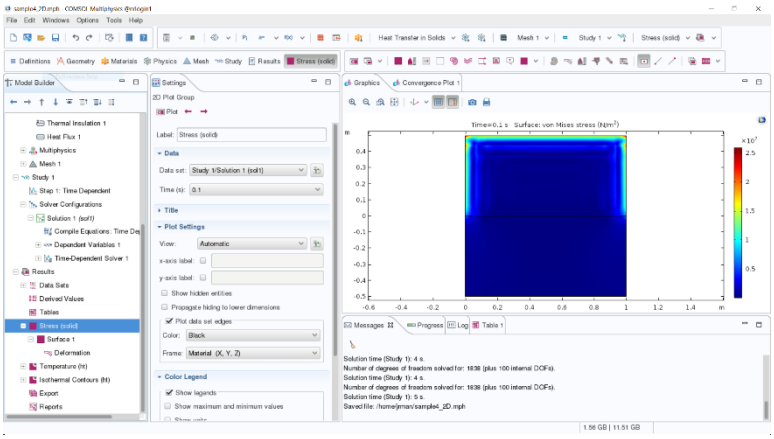
Abstract

Thermal cycling induced residual stress in dissimilar materials systems is a common problem in devices and systems subjected to varying temperature during manufacturing, process, or in service. The resulted high residual stress ultimately leads to crack formation and fracture. Such stress arises mainly due to differences in materials properties such as thermal expansion coefficient and elastic modulus in dissimilar materials. The induced cracking due to thermal cycling is found to cause early failure in systems such as welds on canisters for nuclear waste storage, glass seals in solid oxide fuel cells, and electronics. The two most common methods to assess this failure is by experiments and computer modeling.This research attempts to develop a finite element based multiphysics modeling of thermal cycling induced stress in dissimilar materials systems using an Aluminum-Silicon materials system as a model. COMSOL Multiphysics was the software used to simulate the stress and strain distribution in monolithic Al, Si, as well as bi-layered Al/Si as a function of temperature. The effects of mechanical properties and thermal expansion coefficient on stress developed were evaluated.



The COMOSL Multiphysics software workflow and the layered Al-Si model displaying the stresses induced during thermal cycling

Biography

James Mangahas is a Master of Engineering student (M. Eng) in the Materials Science and Engineering Department at Virginia Tech. James graduated with a Bachelors of Science degree in May 2018. He is expected to graduate in May 2019 due to his enrollment in the accelerated masters program that began his senior year. Working with Dr. Rebecca Cai, James' research has focused on model-based engineering and the benefits it can bring to industry. He recently accepted a job in the Washington DC area working for Booz Allen Hamilton as a Submarine Systems Engineer after graduation.