Calibration of Numerical Model Developed for Failure Prognostics of Automotive ECU Using Moiré Interferometry

LOMSS

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Introduction

- Transfer molding technology can be adopted to mold epoxy molding compound (EMC) over Electronic Control Units (ECUs) to endure harsh operating environmental conditions and reduced the manufacturing cost significantly. Yet the presence of a large amount of outer EMC increased the stresses of ECUs during transfer molding process and operations. The long-term reliability assessment should be conducted to make the technology a more viable alternative to various ECUs.
- Piezoresistive stress sensors have been employed to measure the in-situ stress level inside the packages. But, it only measures the local stress level. In order to understand the stress inside the package, it is necessary to develop an accurate numerical modeling which can link stress sensor data to internal structures of interest for failure prognostics.

Objective

- Develop an accurate numerical model developed for failure prognostic of automotive ECU using moiré interferometry for model verification.

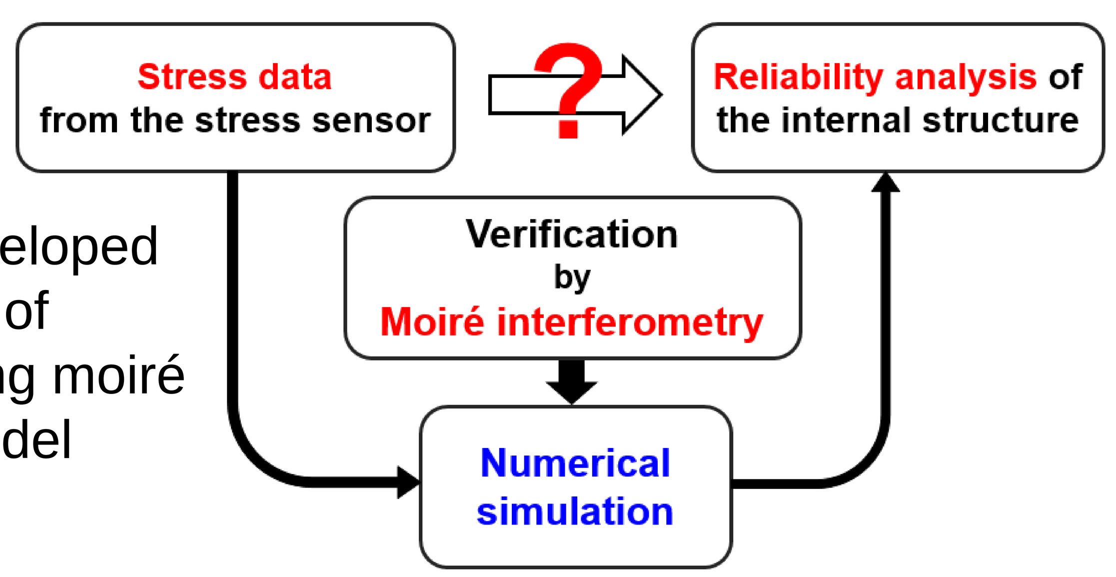


Fig. 1 Use stress sensor data for reliability analysis

Method

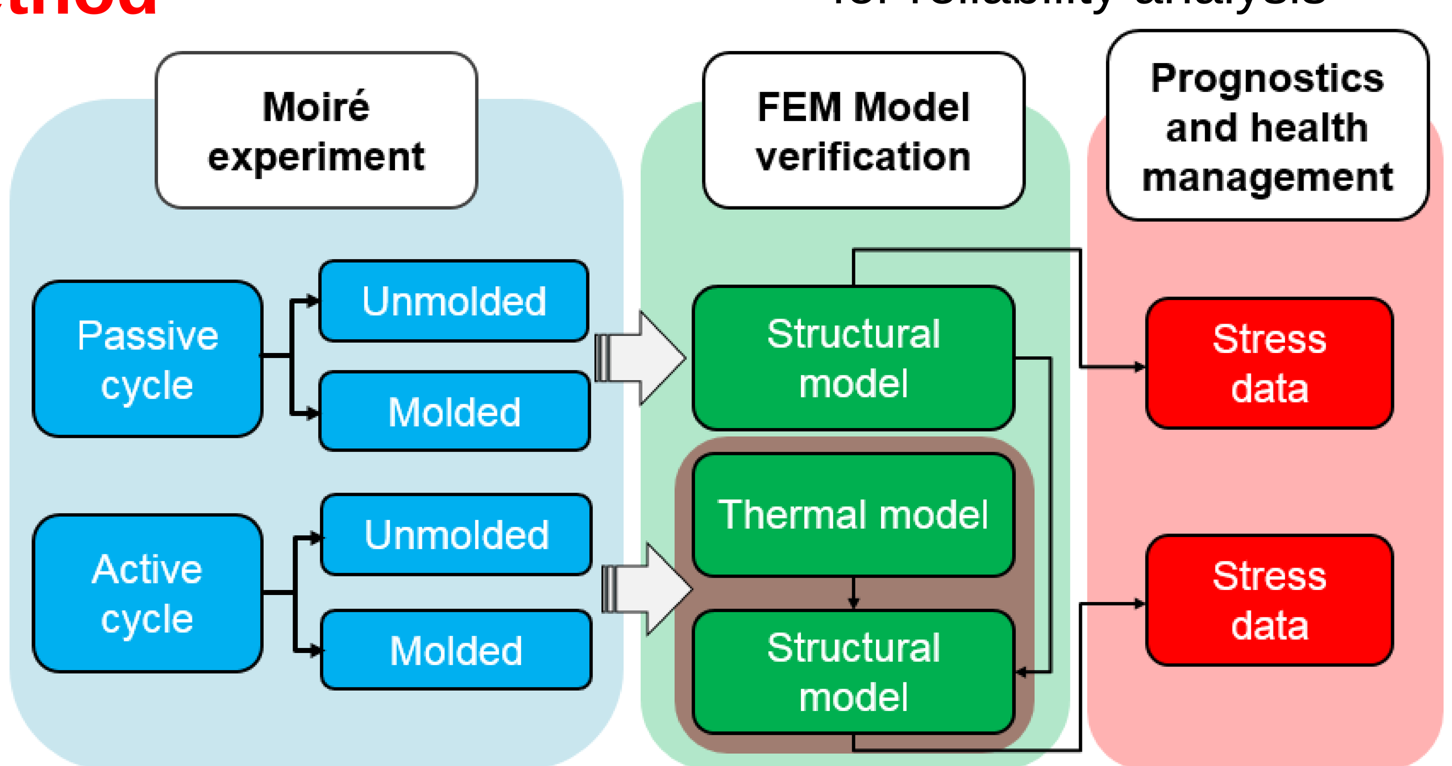
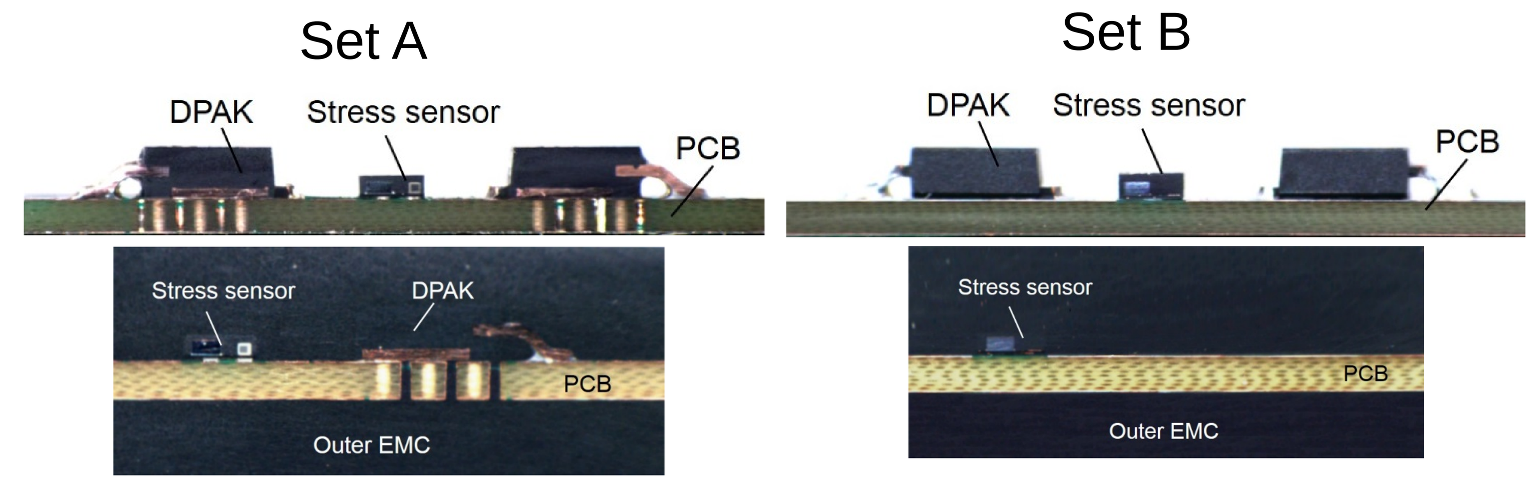


Fig. 2 Flow chart for developing the accurate FE model for failure prognostic and health management of ECU

Experiment and Numerical Validation

- **Specimen preparation**

Specimens were grinded to expose the critical components. Specimen gratings were replicated on the cross section for displacement measurement using moiré interferometry.



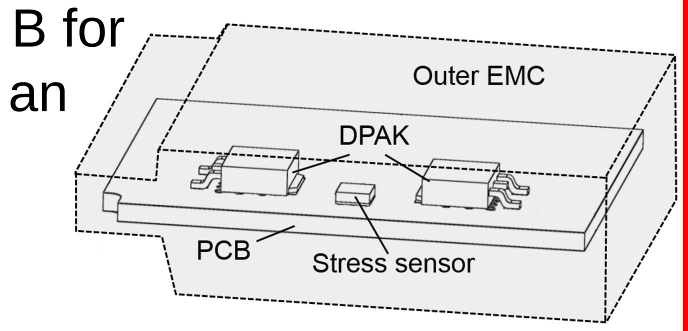


Fig. 3 Set A for passive cycle test and set B for active cycle test. Each set contains an unmolded and molded ECUs.

- **Experimental results**

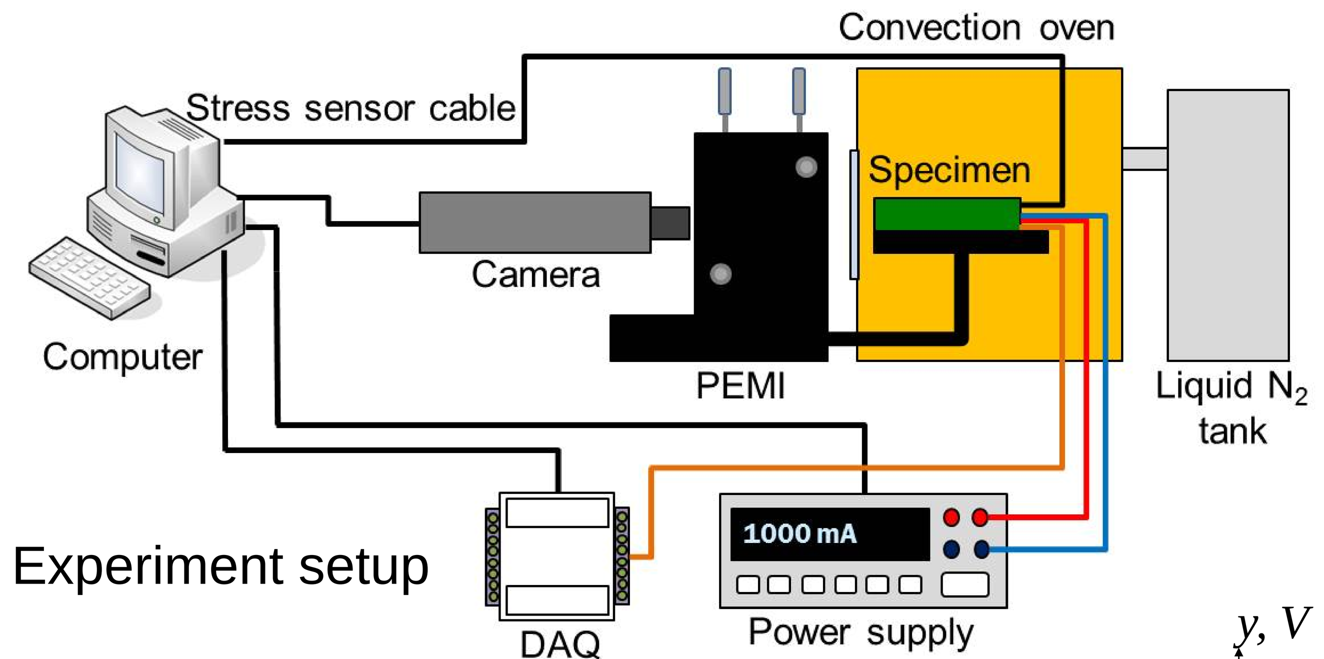


Fig. 4 Experiment setup

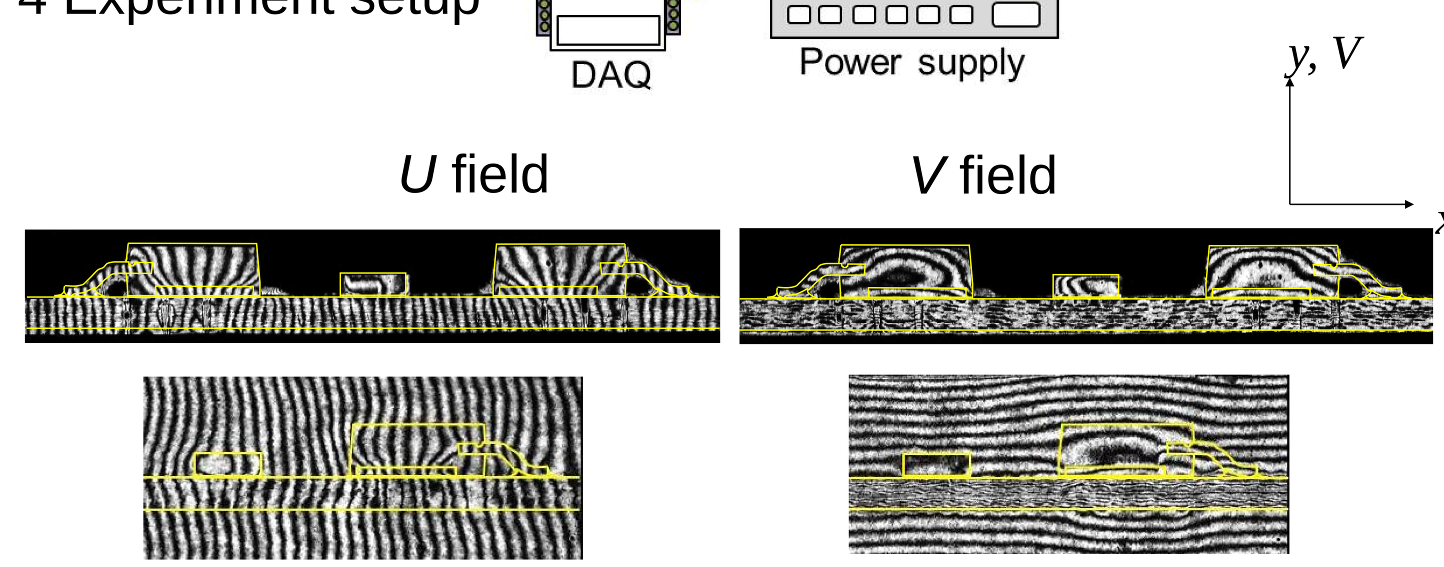


Fig. 5 Displacement fringe patterns measure at -40 °C (passive), where the contour interval is 417 nm/fringe

- **Numerical model verification**

The numerical results deviated from experimental results which means the initial materials are not 100% correct, which need to be calibrated. A supplementary sensitivity study indicates that the CTE has the highest sensitivity to the displacement fields.

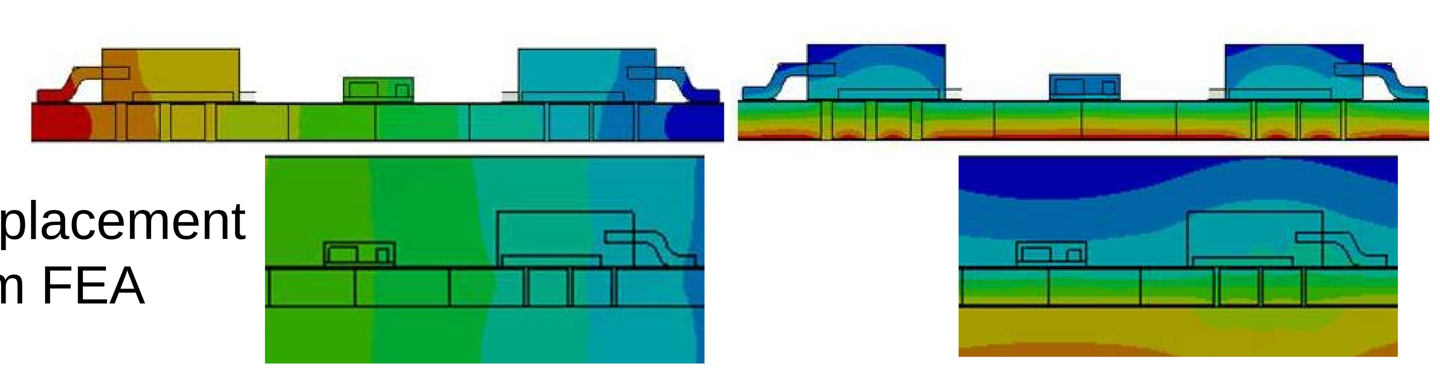


Fig. 6 Displacement from FEA

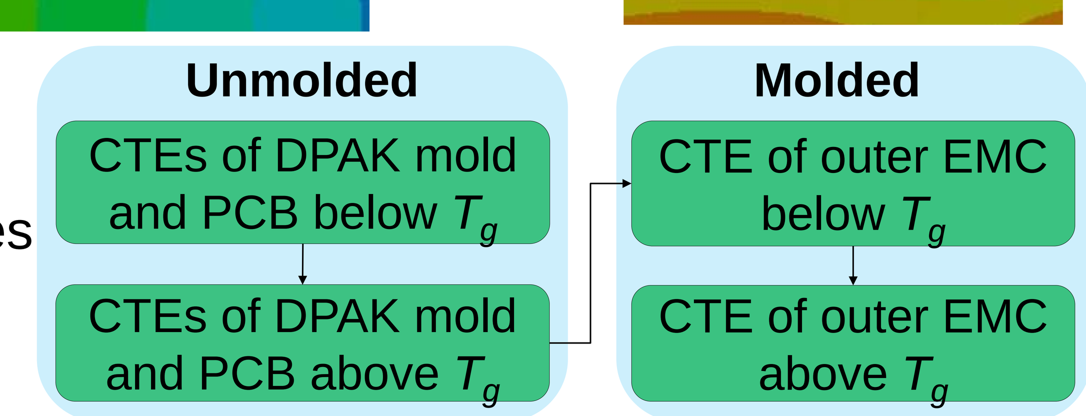


Fig. 7 Material properties calibration procedures.

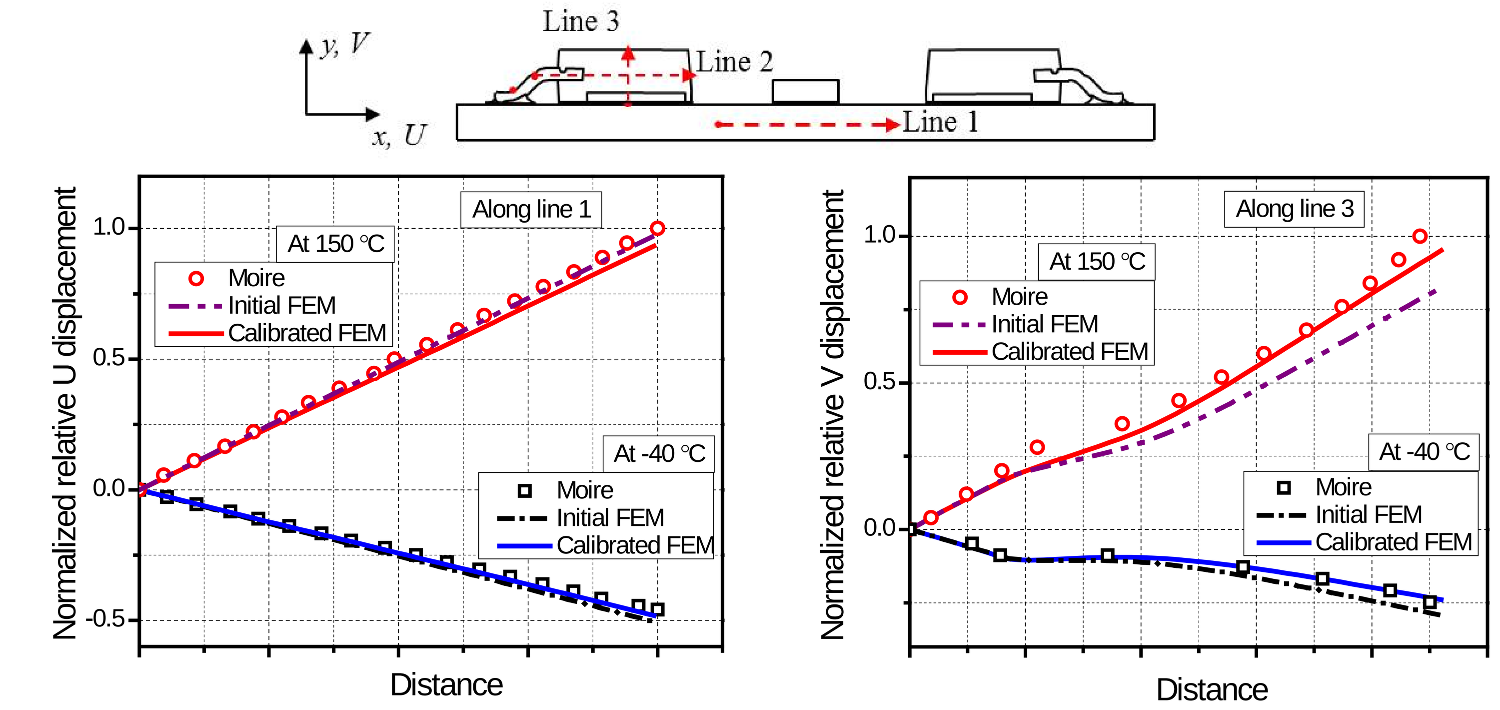


Fig. 8 Comparisons of directional displacements

- **Numerical validation**

The displacement results and temperature measurement from active cycle test were used to corroborate the validity of verified numerical model.

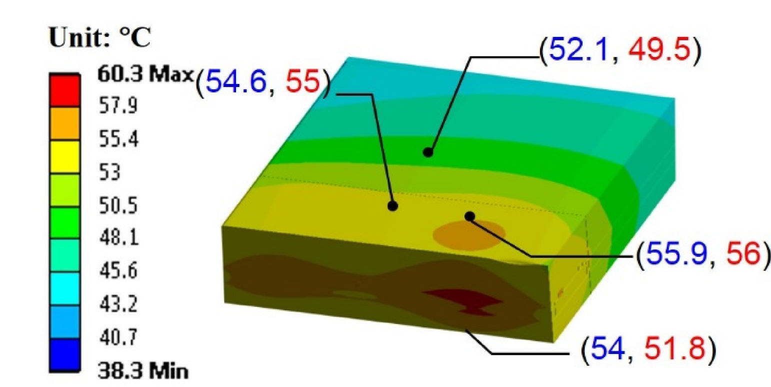


Fig. 9 Temperature distribution from thermal modeling (compared with temperature data points from experiment marked in red)

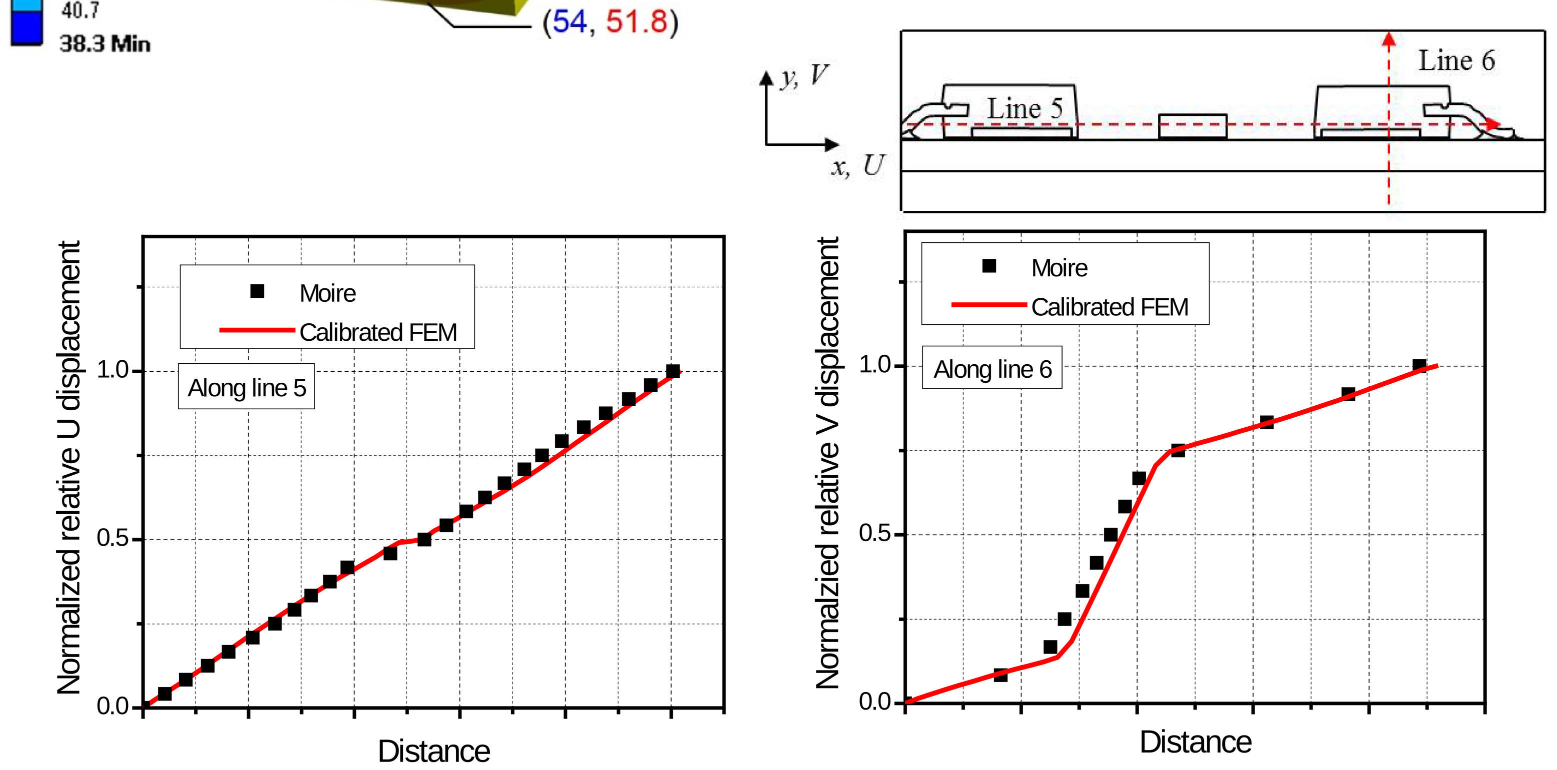


Fig. 10 Results comparison indicates the validity of calibration numerical model.

Impact

Moiré interferometry is a power optical tool for model verification. A numerical model was developed and verified which can be further used for prognostic and health management for ECU coupling with stress sensor.

Related Publication

- B. Wu, et al, "Thermal deformation analysis of automotive electronic control units subjected to passive and active thermal conditions." 2015 16th *EuroSimE.*
- D,-S. Kim, et al, "Electronic control package model calibration using moiré interferometry." 2014 15th *EuroSimE.*