# Measurement Discontinuous Strain Around the Dissimilar Materials Interface Using Global Digital Image Correlation

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**Abstract.** This study shows a method for evaluating displacement and strain distributions around the interface between inclusions and matrix. This method uses global digital image correlation (global DIC). Global DIC can obtain the displacement in inclusions and matrix parts separately using a mesh overlapping an image. Strains are also computed using the mesh. The results observe that the discontinuous strain distribution around the interface can be obtained by Global DIC without smoothing.

## Introduction

Recently, in automobile field, the needs of CFRP (Carbon Fiber Reinforced Plastic) is increasing due to the environmental issues. In order to use FRP composites safely in automobiles, it is important to research the fracture behavior. The mechanical properties of FRP composites is based on those of the constituent fibers or resins and the fiber-resin interface. Therefore, the microstructural damages such as fiber fracture, kink, interface delamination, and microcrack propagation compose the failure of FRP composites. Thus, it is crucial for understanding fracture mechanism of FRP materials to obtain micro-scale strain measurement.

There is DIC (digital image correlation) such as a method of measuring displacement and strain. It has two types of DIC: the subset-based DIC (local DIC) and mesh-based DIC (global DIC). Canal et al. [1] and Mehdikhani et al. [2] suggested that local DIC cannot obtain the discontinuous strains around the interface between the fiber and the matrix because the strains are smoothed during strain calculation. On the other hand, in global DIC [3], the mesh is created overlapping the image, and the nodal displacements are computed from the brightness values in any elements. To use this method, the strains are calculated the fiber parts and the matrix parts separately. Thus, this method is considered to provide strain distribution for discontinuous areas without smoothing.

In this study, a method of measurement displacement and discontinuous strain distribution is investigated by using global DIC to obtain the strain concentration. Then, a specimen simulated the cross-section of CFRP is used.

## Test Method

The image is shown in Figure 1. The specimen is consisted with epoxy adhesive (Hysol EA 9363) and three S45Cs which is 8 mm diameter. The random pattern of white and black by spray paint is on surface of the specimen. The tensile speed is 1.0 mm per minite. The images are taken at 2048×2048 pixels at a rate of 1 fps, with a color depth of 8 bits and a length of about 0.02 mm per pixel. The analysis area is set to 1180×1200 pixels.

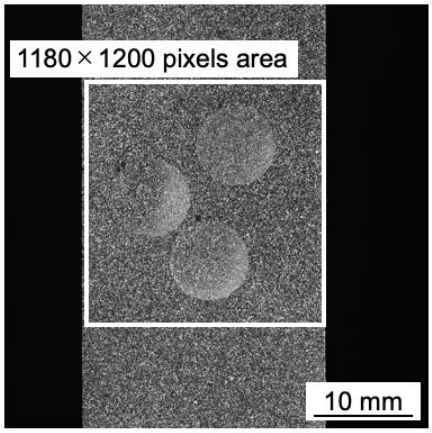



Fig. 1. Random pattern on FRP simulated specimen.

## Mesh for Global DIC

A mesh for global DIC is shown in Figure 2. 3-nodes Triangular primary elements are used in the mesh. The strains are computed based on the displacement-strain relationship of the finite element method using the measured nodal displacements.

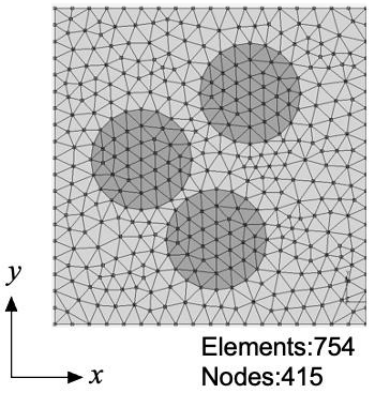
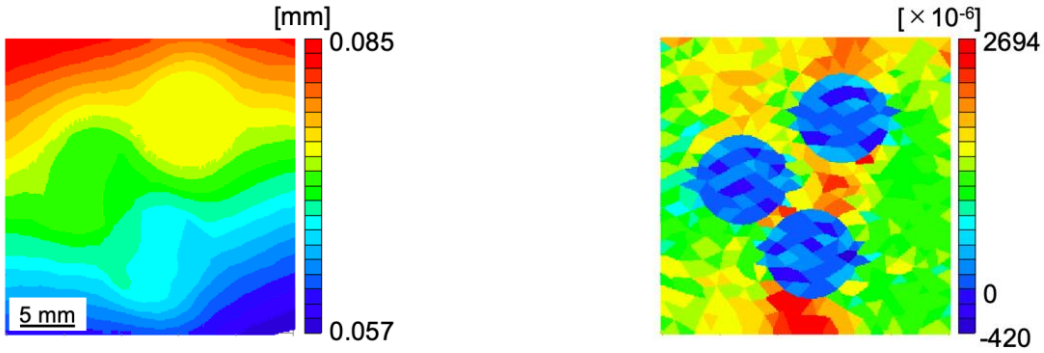



Fig. 2. A mesh with 3-node triangle elements for global DIC.

## Measuring Displacements and Strains by Global DIC

Figure 3 shows (a) y-direction displacement distribution, (b) y-direction strain distribution measured by global DIC.

In the displacements, the continuous distribution is obtained. In the strains, it can be seen that the S45C area is calculated the small prime and the resin part is obtained the large amount strain. Also, the discontinuous strain is shown around the interface between S45C and matrix. In addition, at the matrix part around the inclusions of S45C, the strain concentration is obtained. Therefore, it is considered that Global DIC is effective to measuring micro-scale CFRP.




(a) (b)

Fig. 3. Displacement and normal strain distributions to the loading direction by global DIC (a) $u_y$, (b) $\varepsilon_y$.

## Conclusion

In this study, a method of measurement displacement and discontinuous strain distribution is investigated by using global DIC. The specimen simulated the cross-section of CFRP is used in the test instead of CFRP. The measurement result shows a smooth displacement distribution. In the strain distribution, it is found that discontinuous strain could be calculated without smoothing at the interface. This suggests that global DIC is effective for micro-scale strain measurement of CFRP.

## References

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