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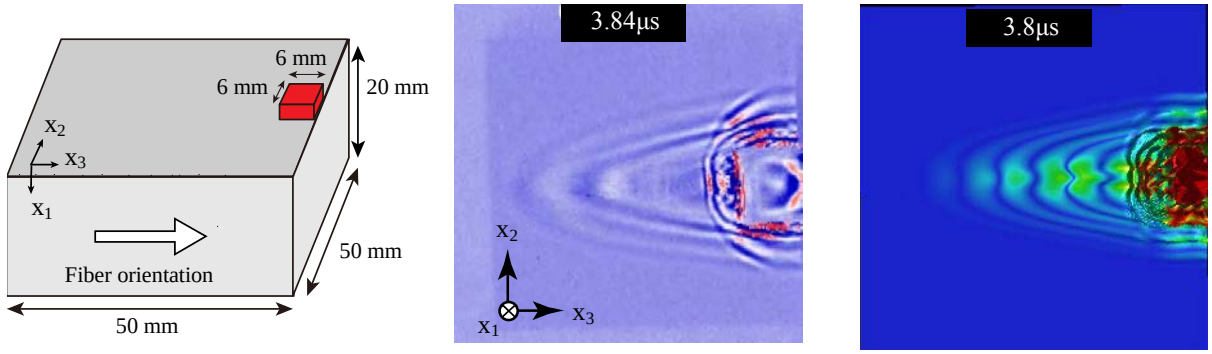
Numerical Simulation of Ultrasonic Wave Propagation in FRP using Image-based Modeling

Naoya Mizokami[1], Kazuyuki Nakahata[1], Keiji Ogi[1], Hisashi Yamawaki[2], and Mitsuharu Shiwa[2]
[1]Graduate School of Science and Engineering, Ehime University, 3 Bunkyo, Matsuyama, Ehime 790-8577, Japan; [2]Center for Structural Materials, National Institute for Materials Science, 1-2-1 Sengen, Tsukuba, Ibaraki 305-0047, Japan

The use of fiber reinforced plastic (FRP) in industrial products and structural materials has been drastically increased in recent years. FRPs are made of a stack of plies, each of which is reinforced by fibers. The ply orientation, ply material, stacking sequence, and number of layers are designed depending on the mechanical requirement. When modeling wave propagation in the FRP for ultrasonic testing (UT), it is important to introduce three-dimensional mesoscopic and microscopic structures because the ultrasonic waves in the FRP are influenced by mechanical interaction between fibers and plastic. Although a numerical approach of full domain is a straightforward method, the discretization of the microscopic structure is not efficient in consideration of the wave length used in the UT. In this study, a finite element method using an image-based modeling [1] is applied to ultrasonic simulation in a carbon FRP (CFRP). Here, the elastic stiffness of a ply is determined with the homogenization method [2], and the three dimensional (3D) mesoscopic structure of the FRP is made by the image-based modeling. 3D finite-element simulations of ultrasonic waves are validated and compared with visualization results obtained with a laser scanning device. Figure 1 shows the results of wave propagation in a CFRP specimen with unidirectionally aligned fibers. The simulation results and measurements showed good agreement with respect to the velocity and spreading of pressure and shear waves.



(a) (b) (c)

Figure 1. (a) CFRP specimen and location of contact transducer (1MHz), (b) visualization of wave propagation with laser scanning device, (c) result with finite element simulation.

References:

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2. K. Terada, T. Miura, and N. Kikuchi, “Digital image-based modeling applied to the homogenization analysis of composite materials,” in *Computational Mechanics*, 20, 331-346 (1997)