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Basic Study for Detection of Microcalcification in Soft Tissue Employing "Twinkling Sign"

"Twinkling Sign"を利用した軟組織中における微細石灰化検出法の基礎的検討

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1. Introduction

"Twinkling Sign" is a phenomenon "rapidly alternating color pixels behind a stationary strongly reflecting medium where an acoustic shadow is expected" [1]. It is said that twinkling sign has a potential in clinical diagnosis. Although researchers have investigated this phenomenon, the occrucence mechanism of this phenomenon is not known yet [2-4]. Our goal is to clarify the occrucence mechanism of twinkling sign, and to develop detection system of microcalcification. In this paper, we observe a behavior of a glass sphere in a fat material by a 3D numerical simulation.

2. Method

In order to induct simulations, finite difference time domain (FDTD) method is employed in this study. 1st Mur is applied for boundary condition. Dirichlet and Neumann boundary conditions are applied between different materials. A simulation model is shown in **Fig. 1**. A glass sphere, which radius is 500 μm, is located in a fat material. Properties of these materials are listed in **Table I**. Each mesh is set as a 10 μm cube, and size of the model is 6 mm (length) × 2 mm (width) × 2 mm (height), thus, the number of used mesh is 24,000,000. Time sampling is set to 1 ns, which satisfies Courant-Friedrichs-Lewy condition, and analysis time is 6 μs (6000 steps). The incident pulse is described in **Fig. 2**, which center frequency is 7 MHz and maximum positive pressure is 5 MPa. After the incident pulse is emitted, the particle velocities of the glass sphere are observed.

Table I: Properties of materials.

	Glass	Fat
Density [kg/m^3]	2240	900
Longitudinal speed [m/s]	5640	1426
Transverse speed [m/s]	3280	0

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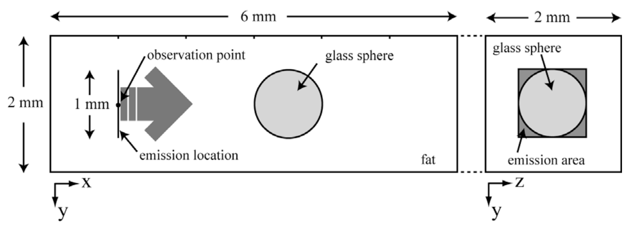

Fig. 1: Simulation model.

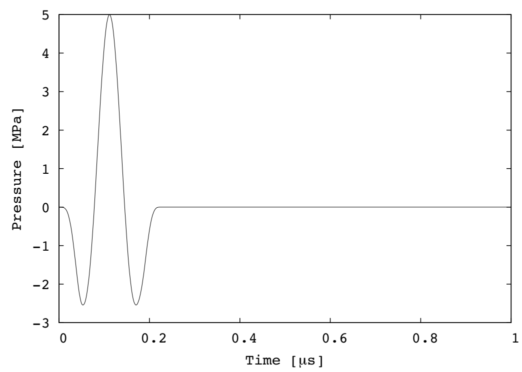

Fig. 2: Incident pulse.

3. Results

Figure 3 describes incident pulse propagation around the glass sphere. It is observed that there are surface waves around the glass sphere. Furthermore, after the surface waves travel around the sphere, the surface waves are transformed into a longitudinal wave and propagates back to the incident point.

To investigate the glass sphere in detail, snapshots of two-dimensional particle velocities at z=1 mm are described in **Fig. 4**. In these figures, each arrow represents the vector of a particle velocity at each point. The length of each arrow is normalized at each time. In these figures, the sound propagates from the front (x=3mm, y=z=1mm) to rear (x=4mm, y=z=1mm) in the glass sphere. In all figures, it can be observed that the front and rear surface points of the glass sphere oscillate in x-direction only.

Besides, the sound propagates not only straightforwardly in the sphere, but also along surface of the glass sphere.

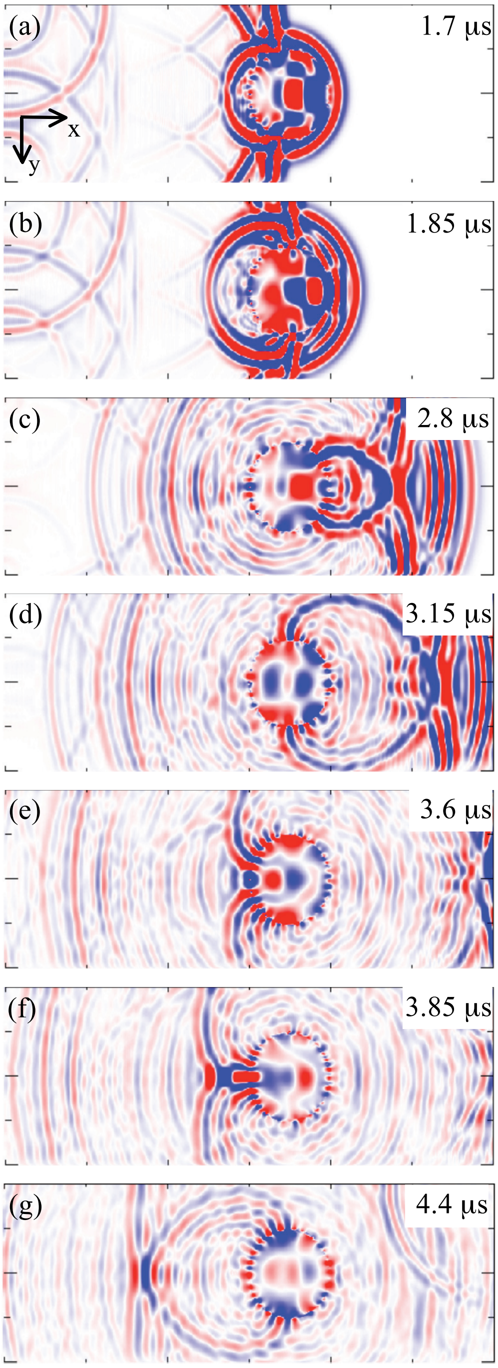

Fig. 3: Snapshots of sound pressure.

4. Conclusion

In this paper, we showed the characteristic behavior of a glass sphere in a fat material by FDTD simulation. From these results, it was found that the surface waves are generated around the glass sphere and are transformed into the longitudinal wave, and that the long duration echo signal is generated. It is presumed that the reverberation of the glass sphere is the key of twinkling sign, but it is not investigated in this paper. As a future work, we will investigate the relationships.

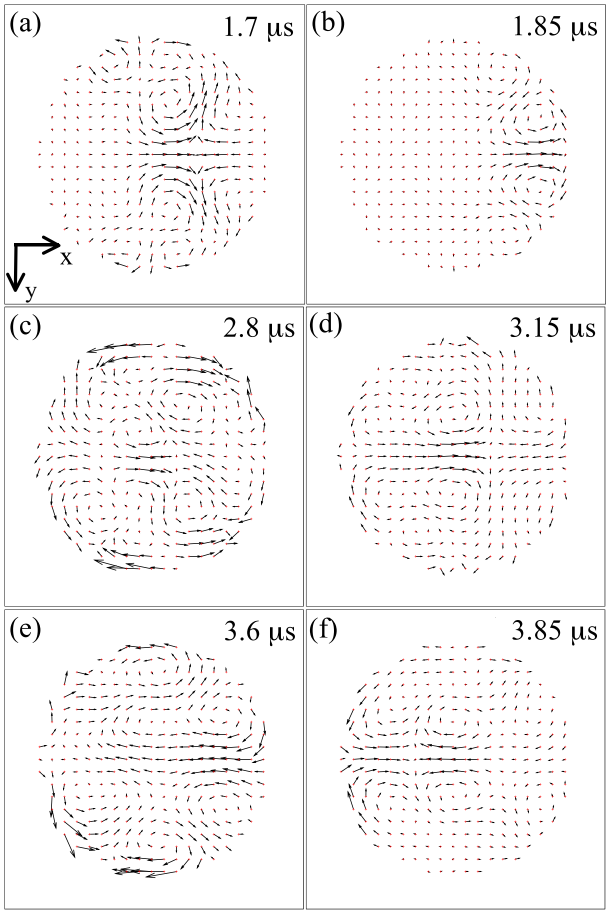

Fig. 4: Snapshots of x- and y- particle velocities in glass sphere.

Acknowledgment

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