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Control of grain dispersion by using flexural standing wave vibration disks

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1. Introduction

The work presented here is of control method of grain dispersion in electroformed diamond blades by using flexural standing wave vibration disks. The electroformed diamond blades are used for dicing and grooving hard-brittle materials such as fused silica and silicon in general. In recent years, the thickness-reducing of the blades and stiffness-improving of the bond materials are required for reducing the karf loss. The grain concentration in the blades also has to be controlled for stable and high quality. Therefore, we are developing the ultra thin blades with composite bonds. In our previous research, the mechanical properties of the nickel electroplating bonds were improved by containing carbon nanotubes as filers[1-3]. However, Grain concentration was not able to be controlled by the method except controlling loadings in precipitation electroplating.

This paper suggests control method of grain concentration by using flexural standing wave vibration disks for periodic arrangement and uniform dispersion of grains on the disk.

2. Experimental procedure

Figure 1(a), (b) show the FEM analysis of two degenerating resonant B13 modes[4, 5] with one node circle and three node lines on flexural vibration disk. These two modes are driven with different phases separated by 90 deg to excite a circumferential flexural traveling wave vibration for uniform dispersion of grains. One of these modes are driven to excite a standing flexural traveling wave vibration for periodic arrangement of grains on the nodes of the vibrations.

Figure 2 shows schematic illustration of a designed flexural vibration disk with four bolt-clamped langevin transducers (BLTs: HEC-301002, Honda Electronics) which are 34 kHz in center resonance frequency, 30mm in diameter and 74mm in length. BLTs are connected to the disk by the horns which are one quarter-wavelength in length. The materials of horns and the disk are stainless steal (SUS304). Figure 3 shows the Cross section A-A' in Fig.1 of a flexural vibration disk. The vibration disk is clamped at outer flange area. The oscillation area , which is connected to the BLT, are 10mm in diameter and the center is on the circle which is 50mm in diameter and the center of the circle is of the disk. The nickel-coated diamond grains which are 10 – 20 μm in grain size are used for grain

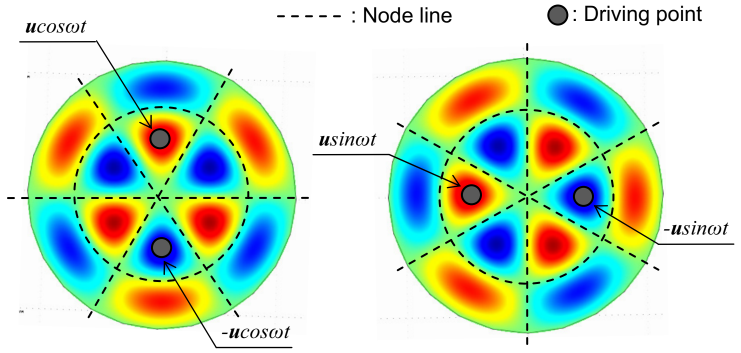


Fig. 1 FEM analysis of two degenerating resonant B13 modes (f_0 = 34kHz) with 1 node circle and 3 node lines on a flexural vibration disk

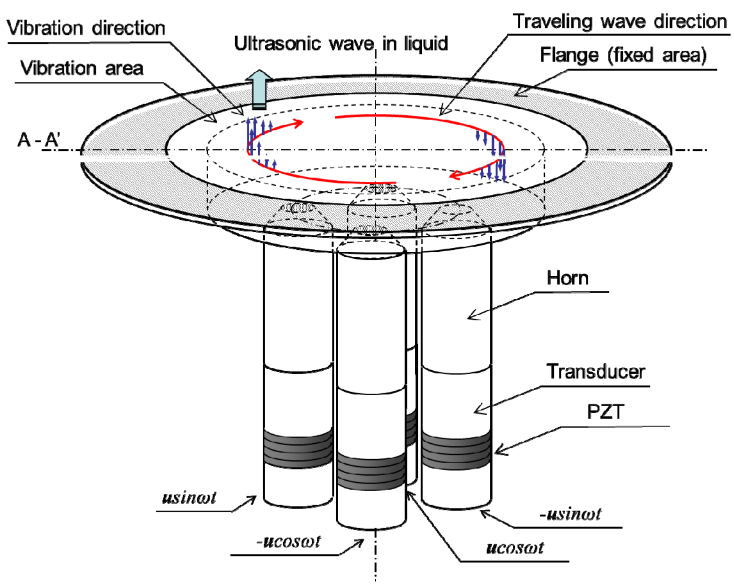


Fig. 2 Schematic illustration of a designed flexural vibration disk with 4 BLT transducers (f_0 = 34kHz) and 4 horns

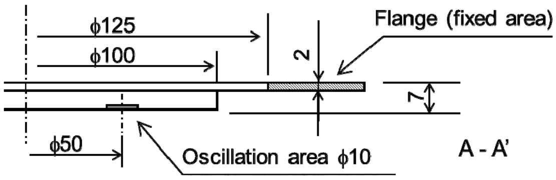
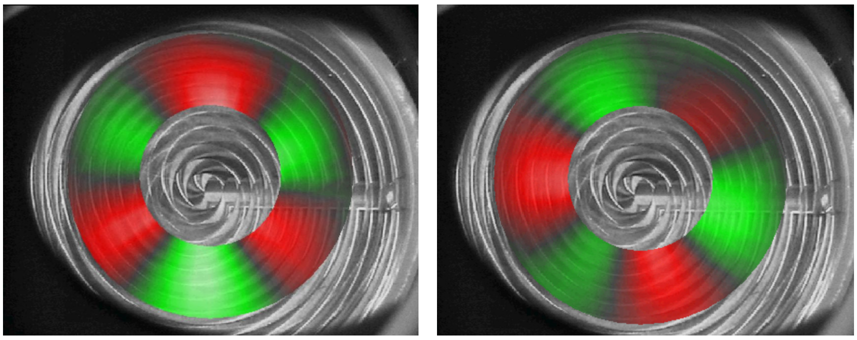
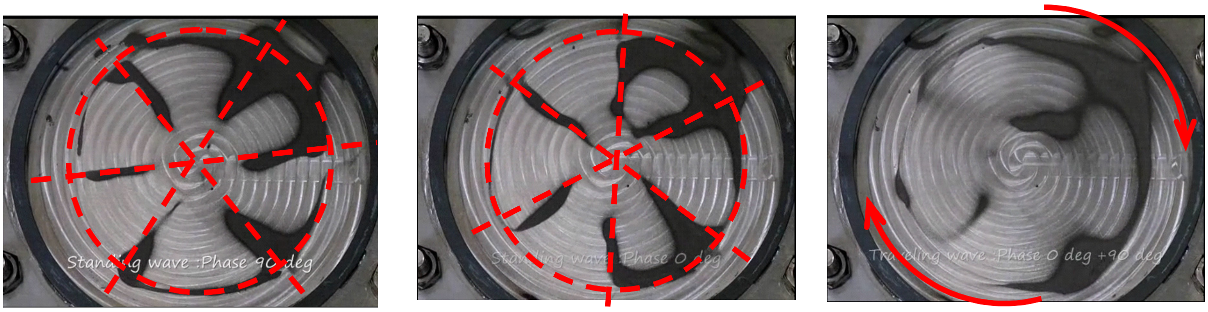


Fig. 3 Cross section A-A' (Fig.1) of a flexural vibration disk (mm)



(a) mode A (b) mode B

Fig. 4 Vibration velocity of standing wave vibration on a flexural vibration disk measured by laser Doppler vibrometer (LDV)



(a) Standing wave (mode A) (b) Standing wave (mode B) (c) Traveling wave (mode A+B)

Fig. 5 Optical images of diamond grains controlled by standing wave or traveling wave on a flexural vibration disk (dushed line : node line of standing wave, arrows : traveling wave direction)

dispersion experiments.

3. Results and discussion

Figure 4(a), (b) show the vibration velocity distribution of two modes on the disk measured by laser doppler velocimetry (LDV). With the node pattern of each mode, the experimental and simulated results are in close agreement.

Figure 5(a), (b) show the periodic arrangement of grains by 60 deg in the circumferential direction. The results show that the grains were trapped on the nodes of the standing waves. On the other hand, figure 5(c) shows the uniform dispersion of grains on the disk by a circumferential flexural traveling wave vibration.

4. Conclusion

The results obtained show that the periodic arrangement and uniform dispersion of grains on the disk can be controlled by two degenerating resonant flexural vibration modes and a phase difference of these modes.

Acknowledgment

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