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Evaluation of ultrasonic spray coating using high intensity and high frequency ultrasonic transducer with hydrothermal piezoelectric films.

水熱合成圧電結晶膜を用いた高周波強力超音波トランスデューサによる液滴吐出と評価

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1. Introductions

Prototype transducers for ultrasonic spray coating devices were fabricated using the self-supporting hydrothermal $KNbO_3$ piezoelectric films of concave shapes. The resonance frequencies of this device was approximately 10 MHz. And the transmitting ultrasound at resonance frequencies were 3MPa. Moreover acoustic streaming and nonlinear acoustics such as cavitation were radiated by high intensity ultrasonic radiation using prototype ultrasonic transducers in above condition. The resultant acoustic radiation pressure was 230kPa. Subsequently, a nozzleless ultrasonic spray coating device was manufactured[1)] by this prototype high frequency and high intensity ultrasonic transducers using the $KNbO_3$ films[2,3)].

In this study, a ultrasonic spray coating device was manufactured. This device ejects droplets from the liquid surface by acoustic energy. Lead nitrate aqueous solution ($Pb(NO_3)_2$ aq) and yeast cells were coated on a glass substrate by this devise.

2. Deposition of piezoelectric $KNbO_3$ films.

As above, to fabricate the high power and high frequency ultrasonic transducers, we needed to obtain piezoelectric materials as thin as possible with high performance. Thus the piezoelectric materials are deposited as described bellow. The $KNbO_3$ films were grown at 240 ºC on Nb-$SrTiO_3$ substrates by the hydrothermal reactions of source materials. Subsequently the obtained 100µm thick $KNbO_3$ films were used prototype ultrasonic transducers.

The hydrothermal $KNbO_3$ piezoelectric thick films were prepared on $SrTiO_3$ single crystal substrates. And then, the obtained hydrothermal $KNbO_3$ piezoelectric thick films were separated from the substrates. In this study, a concave types hydrothermal $KNbO_3$ films were deposited for focusing type ultrasonic transducers.

Prototype high frequency and high intensity ultrasonic transducers using the $KNbO_3$ films were prepared. The back side of active area of ultrasonic transducers has air structures and SMA connectors that are used for high frequency driving. The air structure is a backing material for the purpose of ultrasonic reflection to front of apertures. The piezoelectric $KNbO_3$ films are covered by electrode. And the electrode is connected to signal line and grand line respectively. The radiated ultrasound at resonance frequency was measured by kept hydrophone in degassed water. The hydrophone was maintained at front face of the prototype ultrasonic transducers in degassed water. The radiated ultrasound was determined at receiving sensitivity of the hydrophone. Additionally the signal was utilized burst waves in this measurement.

3. Fabrication of ultrasonic transducers using $KNbO_3$ films

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The ultrasonic transmitting and receiving properties of a prototype ultrasonic transducer was measured in degassed water with Pulser Receiver (Olympus 5910PR). A time wave form of transmitting and receiving using the prototype ultrasonic transducer and a power spectrum of the time wave form were measured. In this case, a peak was excited at 10 MHz by resonance phenomena. And then, the high power characteristics of prototype ultrasonic transducers were measured at this resonance frequency.

4. Evaluation of ultrasonic spray coating

Figure 1 shows an experimental setup for an ultrasonic spray coating with the high power and high frequency ultrasonic transducers. Raw materials were prepared $Pb(NO_3)_2$ aq as in-organic materials of crystal, and yeast cells as organic materials.

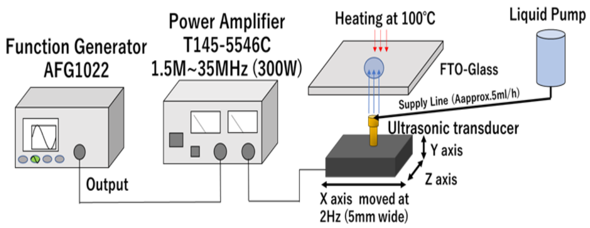

Fig.1 experimental setup for ultrasonic spray coating with high power and high frequency ultrasonic transducers

Figure 2 and 3 shows a laser microscope photograph and XRD-patterns of surface of as-deposited the $Pb(NO_3)_2$ on the glass by this device. The surface-photograph indicates that a $Pb(NO_3)_2$ crystal layer is formed from the droplets.

Figure 4 shows a laser microscope photograph of surface of as-deposited the yeast cells on the glass by this device. The surface-photograph indicates that a yeast cells is formed from the droplets. And then, we confirmed died or not of this cells. As a results, the yeast cells were alive as active increases.

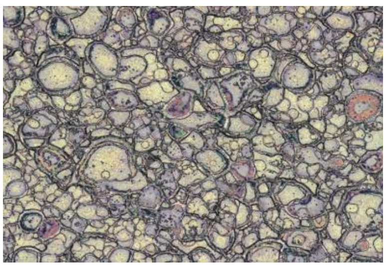

Fig.2 the surface-photograph of as-deposited $Pb(NO_3)_2$.

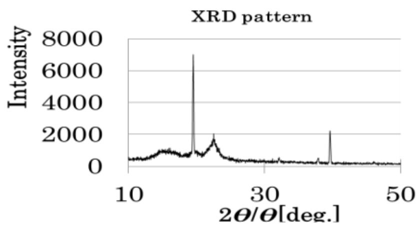

Fig.3 the X-ray diffraction pattern of as-deposited $Pb(NO_3)_2$.

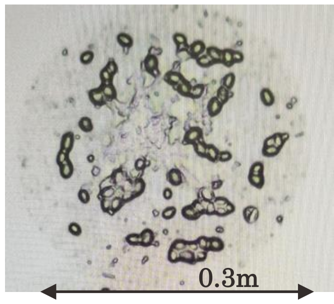

Fig.4 the surface-photograph of as-deposited yeast cells.

5. Conclusions

We proposed to new ultrasonic spray coating devices using the high intensity and high frequency ultra-sonic transducers. In particular, it is important to utilize a high intensity and high frequency ultra-sonic transduce such as sound pressure of 3MPa at 10MHz. And then, we got two-types good results as deposition of in-organic crystals and organic materials.

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