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Development of removal process of burrs and scraps generated by short pulsed laser processing for metallic thin foil by applying ultrasonic cavitation.

超音波キャビテーションによる金属箔のレーザー加工バリ，スクラップ除去法の開発

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1. Introduction

Cavitation often occurs in liquid when the local pressure of the liquid decreases intensively. It is known that high impact pressure is induced at a moment when the bubbles collapse and stable continuous cavitation can be generated by ultrasonic wave irradaiation in liquid.

It have been reported that the high impact pressure caused by micro jet which occur when a cavitation bubble collapse could rearch about 1 GPa[1] which is intensive enough to deform metallc material such as stainless steel. We have investigated the surface treatment process , the intensive impact pressure caused by ultrasonic cavitation applying on metallic surface to introduce compressive residual stress such as shotpeening.[2]

Removal process of burrs generated by some of mechanical process, for example Grinding, Shot-blasting process, Wet-blasting, Water-jet peening and so on are well known process for finishing of surface or edge of bulk material for industrial products. However, since a lot of defects in surface layer are induced by shot corrision, low stiffness or strength material could be damaged significantly.

Since cavitation is repetitive phenominon at dispersed microscopic local areas, the process can apply intensive impact pressure only to top of surface layer. Therefore the cavitation process probably has advantages for the small parts and thin films, because it can inhibit production of surface defects.

Metallic thin foil of Al, Cu, and other material is used for industrial parts. For example, Al, and Cu for electrode collector of Li-ion battery, austeniteic stainless steel such as SUS304 for steel belt conbayor. The thin foil is pierced in roll to role process via mechanical punching, chemical etching, and laser-processing to provide additional function for example, adhesion, wettability with expanding surface area, and penetration efficiency by micopore with high open area ratio. Especially in mechanical or laser proccessing, removal process of burrs and scraps must be required absolutely.

In this study, we tried to apply the ultrasonic cavitation to remove burrs and scraps generated on Cu thin foil by short pulsed laser processing.

2. Experimental

Ultrasonic wave of frequency 19.5kHz was oscillated with an ultrasonic transducer and was irradiated to surface of a specimen fixed on basement of the vessel with magnet plates in ethanol of RT. The specimen with the vessel on the motor-driven slide table could be moved holizontally at a configured constant speed. The step horn of which the diameter is ϕ50-ϕ25 was used. The horn material is stainless steel, SUS303. **Fig.1** shows the schematic of an experimental set-up. The axial vibration direction of the horn is vertical to the specimen surface.

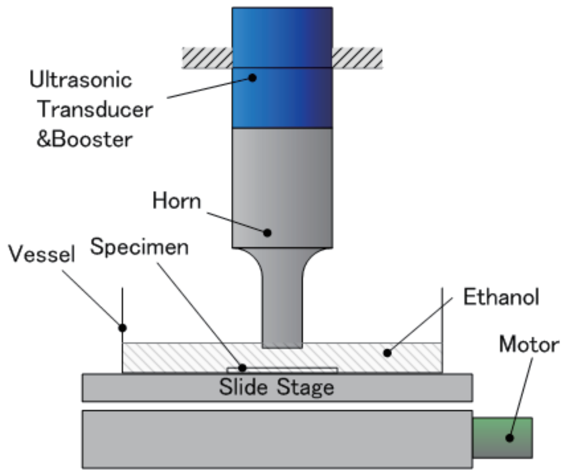


Fig. 1　Experimental set-up.

The specimen material is Cu foil of 25μm thick. Test pieces were cut of the size of 35mmx35mm.The laser-prosessing area is 20mm x 20mm, center of the test piece. The conditions of the ultrasonic cavitation and the laser-processing are shown in **Table.I** and **Table.II** respectively.

Table.I　The conditions of the ultrasonic cavitation

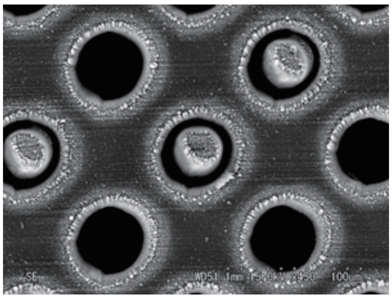
Ultrasonic waveform	Sine	
Ultrasonic frequency	19.5	kHz
Repetitively driving waveform	Pulse	
Repetition pulse frequency	20	Hz
Pulse On-Duty	10	%
Stage scan speed	10	mm/s

Table.II　The conditions of the laser-processing

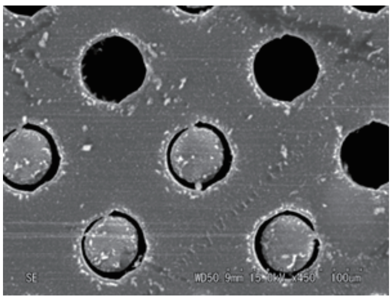
Wave length	355	nm
Repetition pulse frequency	200	kHz
Laser power	3	W
Laser scan speed	1.5	m/s
Diameter of aperture	48	μm
Pitch(x)	123.7	μm
Pitch(y)	125.8	μm
Open area ratio	23.2	%

3. Results and Discussion

To evaluate the effect of the ultrasonic cavitation to remove burrs and scraps generated by laser-processing without destruction of foil, the surfaces of laser-light incident and emitting side were observed by SEM. **Fig.2** and **Fig.3** show the no-applied surface after the laser-processing, and the surface that the ultrasonic cavitation applied respectively.

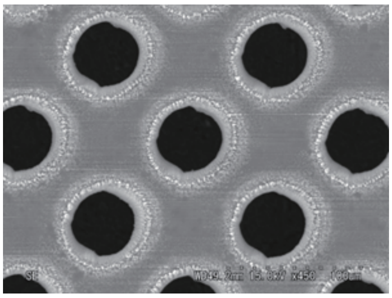


(a)　incident side

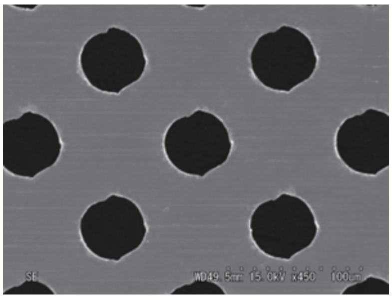


(b)　emitting side

Fig.2　SEM observation of no-applied surface after laser-processing.



(a)　incident side



(b)　emitting side

Fig.3　SEM observation of surface that the ultrasonic cavitation applied.

In **Fig.2**(a), burrs are observed along the line with circle of the apertures and in **Fig 2**(a) and (b), scraps are partly retaind in apertures. On emitting side , a lot of scattering contaminations are obserbed in **Fig.2**(b), but then on incident side surface, such contaminations are hardly obserbed.

Cavitaion was caused in ethanol between tip of the horn and the specimen surface. The specimen was feed holizontally to scan whole area of the specimen surface. In **Fig.3**(a),(b) the burrs, the scraps and the contaminations could be removed significantly.

3. Conclusion

It is confirmed that ultrasonic cavitation achieved to remove burrs, scraps and contaminations generated on metallic thin foil by short pulsed laser processing without destruction and deformation of the foil. It is suggested that the process investigated in this study can be applied in role to role process by designing and manufacturing adequately bar type horn with large enough for a rolled foil width.

References

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