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Synthesis of Fine Particles Coated with Carbon by Laser Ablation in Liquid

- Relationship of Generated Ni-particle Diameter and Laser pulse width -

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Abstract: In this study, we attempt to generate carbon-coated fineparticles by liquid-phase laser ablation. Solvent of liquid-phase laser ablation was selected ethanol as carbon source. As a result, the diameter of spherical particle was 3 to 10 micrometers, observed by a scanning electron microscope. The size of spherical particle was changed in accordance with pulse width of laser.

1. Introduction

It is known that ganerated fine; micro and/or nano, particle is different property from bulk material. Taking advantage of the characteristic, fine particles are used for wide field, including medical care, energy, and imformation technology. One of them, applying to a material of high-density magnetic recording[1] or a magnetic fluid[2] using magnetic body particles are expected. However, it is a problem that the magnetic characteristic is lost remarkably owing to the particle surface oxidizing. For this reason, in order to protect the characteristic of particles, research which coats particles with carbon[3] or an oxide[4] are popular. Incidentally, there is liquid-phase laser ablation in the generation method of particles. Characteristics of the method are not need many devices and low cost. And, because generated particles stay in a liquid, collection is easy. We examined supplying carbon and carrying out a carbon coat by making into ethanol solution used by the liquid-phase laser ablation. In addition, pulse width of the laser to be used is a milli second for micro-particulation. When generating nano-particulates, pulse width of nano second or femtosecond is usually used. Because, we would like to carry out thermal decomposition of the ethanol and coat with the carbon using thermal energy. In addition, since a long wavelength induces thermal energy, laser to be used is a fundamental wave of Nd:YAG laser (1064nm). Check of the ablation in the inside of ethanol, and generation and observation of micro and/or nano particles are performed in this study.

2. Experimental methods

2.1 Measurement of emission spectrum of ablation plumes.

Fig. 1 shows experimental apparatus of liquid-phase laser ablation. A quartz cell (10×10×45 mm) was filled with ethanol (C_2H_5OH, 99.5%) and Ni target (10×10 mm) was put in it. Nd:YAG laser (Toshiba, LAY-603-OAJ, wavelength: 1064 nm, (pulse width: 0.5 to 5.0 ms, flash lamp discharge voltage: 700 V). The focused laer beam (f = 100 mm) was irradiated to Ni taeget , and emission of ablation plumes were observed. Emission of this apectra were mesured by a optical sprctroscope (StellarNet, EPP2000-UVN-SR).

2.2 Synthesis of carbon coated micro and/or nano particle

Carbon coated micro and/or nano particle were grown by liquid-phase Nd:YAG laser ablation. The laser pulse width, flash lamp discharge voltage, irradiation time and frequency for experiments were set as 1~5 ms, 600 V, 5 min, 1 Hz, respectively. After irradiation, the Ni taeget was taken out of the quartz cell, a Si substrate (single crystal, 10×10 mm) was dipped into the cell. Carbon coated micro and/or nano particle were deposited on the Si substrate by varporization the liquid in quartz cell. Carbon coated micro and/or nano particle on the Si substrate were observed by scanning electron microscope (SEM, Hitachi, S-3000N).

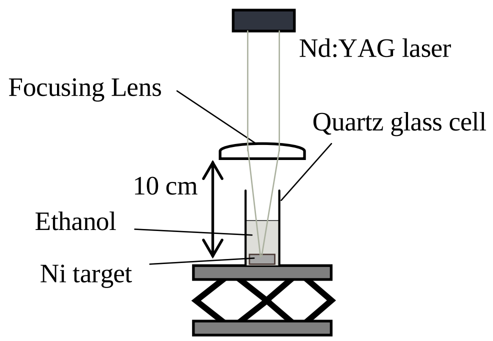

Fig. 1 Experimental apparatus of liquid phase laser ablation

3. Results and disscution

Fig. 2 shows emission spectra of ablation plume. It is difficult to identify the emission peak, because emission intensity is very weak, and there are large amount of electrical noise. Emission intensity from 685 nm to 693 nm are increased by increasing the laser pulse width. According to spectrum database of NIST, there are many emission

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peaks, which due to Ni(I) 691.5 nm, O(II) 692.2 nm and O(II) 693.6 nm. Therefore, it is suggested that luminescence becomes strong by increasing pulse width increase.

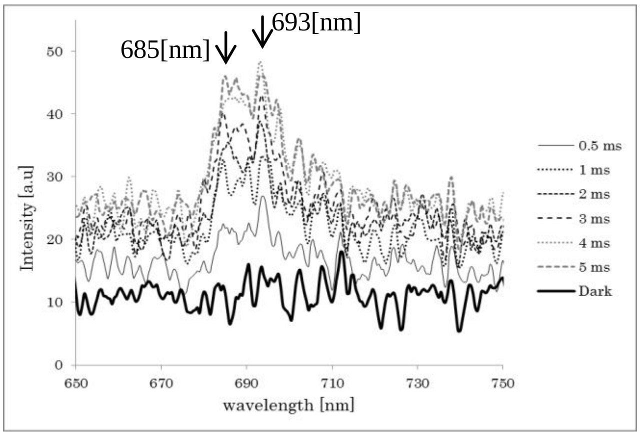

Fig. 2 Emission spectrum of ablation plume

Fig. 3 (a) is SEM image of the carbon coated particles gnerated at 1 ms pulse width. Fig. 4 and 5 shows the case of where 3 and 5 ms pulse laser was used, respectively. Respectively, particles are generated. As three figures suggests, that the diameter of particles were decreased by decreasing pulse widths. Relashionship between pluse width and diameter of particcles is shown in Fig. 6. Particle diameter is decreased with decreasing amount of pluse width.

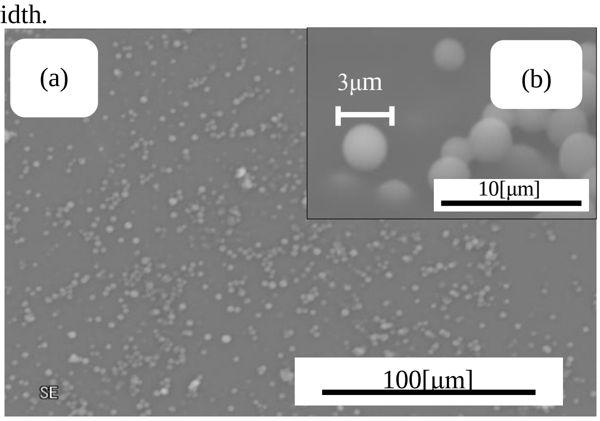

Fig. 3 SEM images of generated particles with 1 ms pluse width. (a) A low magnification image. (b) A High magnification and 45-degree tilted image.

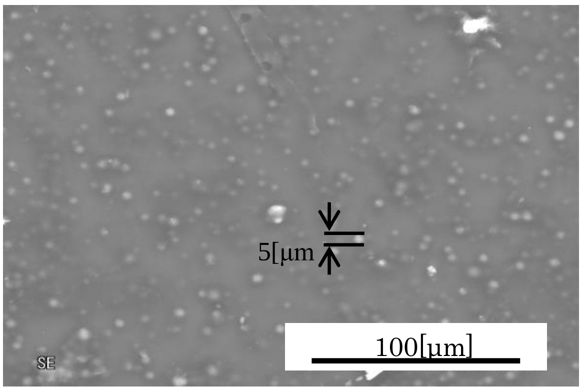

Fig. 4 SEM image of generated particles with 3 ms pluse width.

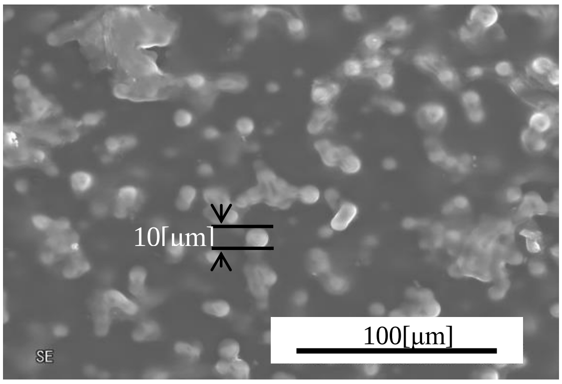

Fig. 5 SEM image of generated particles with 5 ms pluse width.

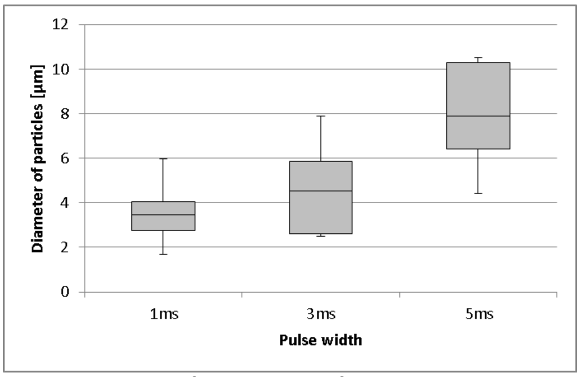

Fig. 6 Distribution of the diameter of a particle by pulse width.

4. Conclusions

In this study, we generated carbon coating metal particles by liquid-phase laser ablation, in order to apply to material of high-density magnetic recording or a magnetic fluid. Diameter of the carbon coating metal particles were decreased 10 micro meter to 3 micro meter by decreasing pluse widths. In Measurement of emission spectrum of ablation plumes, since the peak of nickel had weak emission intensity, it was not able to specify. The emission intensity of 685 nm to 693 nm increased by increasing pluse widths. Future subjects are observation of the cross section structure of carbon coating metal particles, and application to material of high-density magnetic recording or a magnetic fluid.

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