# Laser Induced Thin Film Production (LITFP) Using Nitrogen ($N_2$) Laser Deposition

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**ABSTRACT**

Laser induced thin film production (LITFP) technique was employed for making Lead (Pb) thin film by nitrogen laser ablation in miniature scale. The energy of nitrogen laser operated at 12.5 kv, 90 torr was 3.5 mJ with 5 ns pulse duration, thus producing peak power at around 0.7 MW. Pb plasma of 1 cm diameter was generated in each laser bombardment, producing thin film above the glass substrate. The thin film characteristics were measured by the thickness and surface morphology using scanning electron microscope (SEM). It was proved that there was a linear relationship between the number of laser shots and film thickness.

Keywords: Thin film, nitrogen laser deposition

## INTRODUCTION

Nowadays, the thin film technologies are widely used for producing miniature scale components such as microelectronic and microoptics. There are many methods for making thin films (Dietze & Becker 2005), among them are: sputtering method, thermal and electron beam evaporation, molecular beam deposition, and laser induced thin film production (LITFP). In this work, we employed method of LITFP for making Pb thin films.

Pulsed laser deposition is an interesting method, since it has advantage namely: the method involves the interactions of high intensity laser pulse with solid target, therefore deposition could be performed in a clean vacuum or non reactive gases; another important advantage is the ability to transfer the composition of the target to the deposited film. Because of these advantages, the method has been widely used for preparation of various materials such as superconductors, semiconductors, and dielectrics (Venkatesan *et al*. 2002). Laser plasma could be generated in a reduced pressure of gas (1 torr) by focusing high power laser pulse onto solid target surface. The target is vapor generated by this interaction was deposited on a substrate. The quality of this film depends on the laser parameters (Uchiki *et al*. 1992), i.e. pulse energy, pulse width, power density and substrate temperature.

## METHODS

In this study, we tried to form a thin film by using a nitrogen laser. The laser light was directly focused onto a Pb surface in a reduced pressure of air (1 torr). The target's vapor was deposited on a substrate which was placed 1 cm and 45$^o$C from the target. The characteristics of the film were measured by means of their thickness and surface morphology using scanning electron microscope (SEM). Figure 1 shows the experimental setup. The $N_2$ laser radiation was focused at an incidence angle of 45$^o$Cby a quartz lens (f=100 mm) through quartz window onto the surface of the sample. The $N_2$ laser (pulse energy 3.5 mJ, pulse duration 5 ns) was operated at 2 Hz repetition frequency. The sample (Pb sheet of 99.999% purity) was placed inside the vacuum chamber, that was reduced pressure of air ( 1 torr) using rotary pump.

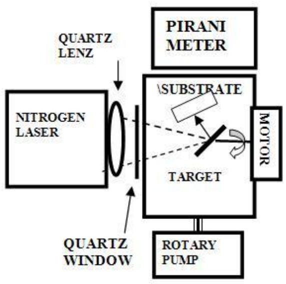


Figure 1. Experimental Setup. The Pb plasma was generated due to the laser irradiation and part of the blow off material was deposited on the substrate surface. In these experiments, we made Pb film by using 4200, 6000, 7800 and 9600 laser shots respectively.

Before placing, the sample and glass substrate, size (2×20×50) mm were cleaned using liquid soap and aquadestilate, heated using aquadestilate for 10 minutes and cleaned with ultrasonic vibrator. At the final step ethanol was used in place of aquadestilate and treatment was done for 5 minutes. The target's vapor was deposited on a substrate which was placed 1 cm and 45$^o$ from the target.

## RESULTS AND DISCUSSION

The thickness and surface morphology of Pb thin film were determined using scanning electron microscope (SEM). Before measurement, the substrate was cut in 1 cm x 1 cm rectangular form and coated with other metallic material of 300 thicknesses using sputtering machine. The substrate was placed vertically in order to measure the film thickness and horizontally to analyze the surface morphology.

Figure (2a), (3a), (4a) and (5a) show photograph of Pb film thickness after irradiation of 4200, 6000, 7800, and 9600 shots respectively, The thickness of the film was 0,5; 0,7; 1,0; and 1,2 µm

Figure 2a. Photograph of Pb thin film produced, after 4200 laser shots irradiation. The thickness of the film was 0.5 µm.

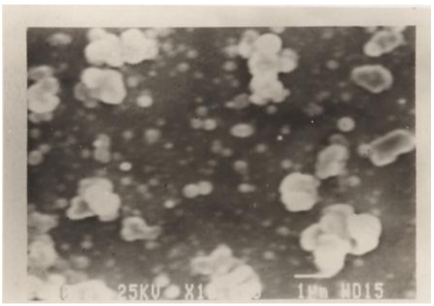

Figure 2b. Photograph of Pb film surface morphology after 4200 laser shots irradiation.

Figure (2b), (3b), (4b), and (5b) show photograph of the surface morphology after irradiation of 4200, 6000, 7800, and 9600 shots respectively. It is seen that the surface morphology become more homogenously at higher laser shots. Fig (5b) shows a homogen Pb film such as an island thin film, after 9600 irradiation of laser shots.

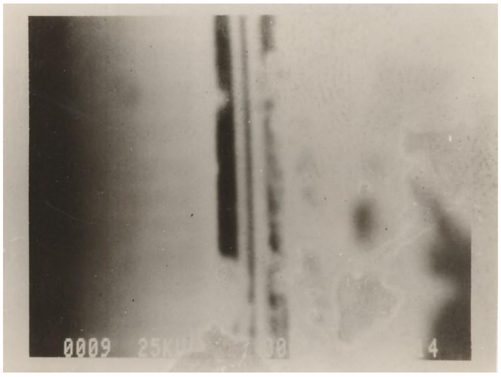

Figure 3a. Photograph of Pb thin film produced, after 6000 laser shots irradiation. The thickness of the film was 0.7 µm.

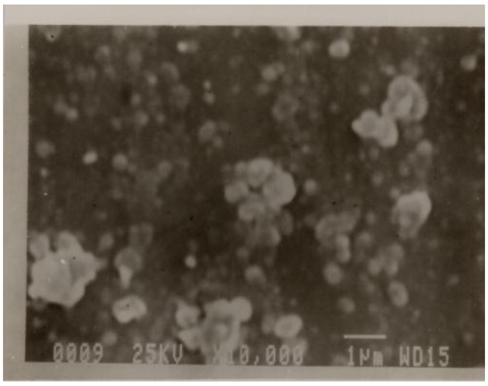


Figure 3b. Photograph of Pb thin film surface morphology after 6000 laser shots irradiation.

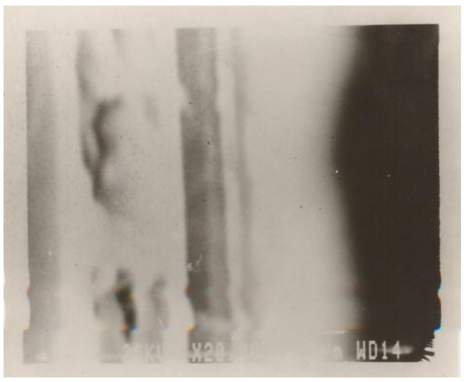

Figure 4a. Photograph of Pb thin film produced, after 7800 laser shots irradiation. The thickness of the film was 1 µm.

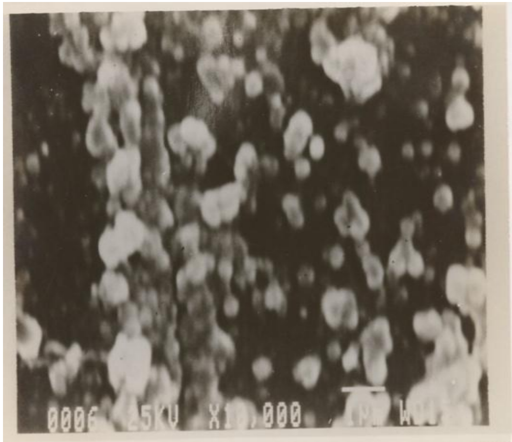

Figure 4b. Photograph of Pb thin film surface morphology after 7800 laser shots irradiation.

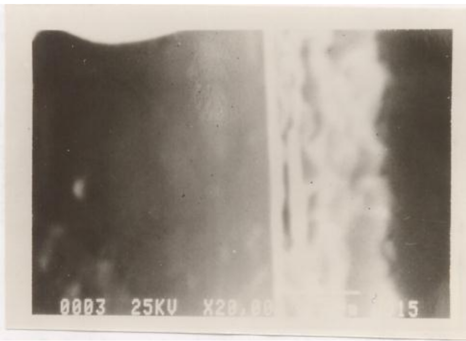

Figure 5a. Photograph of Pb thin film produced, after 9600 laser shots irradiation. The thickness of the film was 1.2 µm.

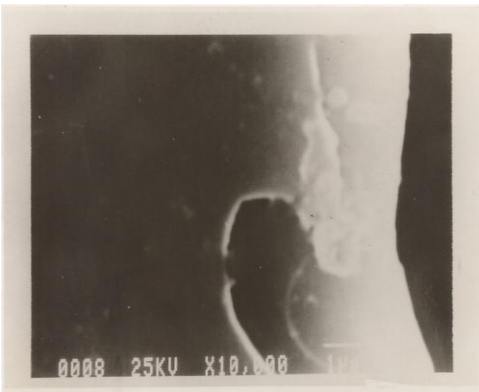

Figure 5b. Photograph of Pb film surface morphology after 9600 laser shots irradiation.

From Fig (2a), (3a), (4a) and (5a) we can derive the relationship between laser shots and film thickness. Fig (6) shows the relationship between the number of laser shots and film thickness.

In this research, we also tried to compare the results with Brass film made using excimer laser such as in figure 7a and 7b.. The experimental procedure is essentially the same as before. The excimer laser (QUESTECK model 2000) was at XeCl mode (308 nm, 100 mJ and 10 ns (Kagawa 1992).

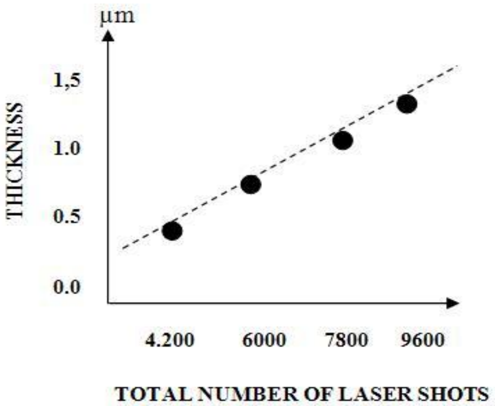


Figure 6. Relationship between the number of laser shots and film thickness.

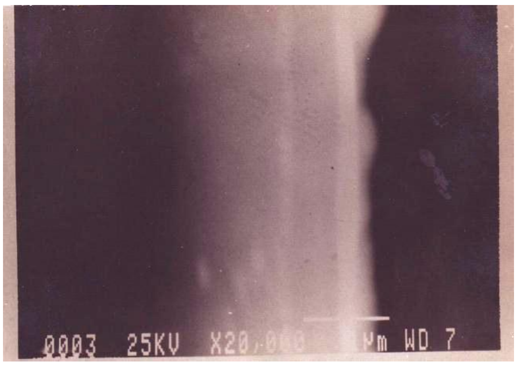

Figure 7a. Photograph of brass film produced after 5000 excimer laser shots, The thickness of the film was 0.7 µm.

Besides film thickness, surface morphology other characterization of the thin film such as Xray diffraction, Raman spectra and photo luminescence spectra were not carried out due to the limitation of equipment.

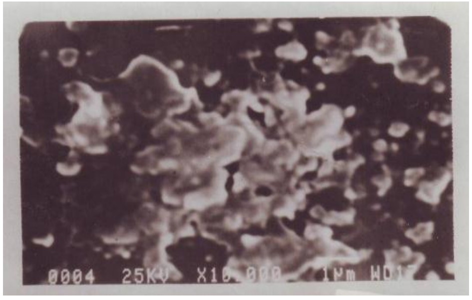


Figure 7b. Photograph of brass film surface morphology after 5000 excimer laser shots irradiation.

## CONCLUSION

We have proved that laser induced thin film production could be done by using nitrogen laser at relatively low power. From the experimental result, we have proved that there is a linear relationship between the number of laser shots and film thickness. The surface morphology of the thin film island of 9600 laser shots was performed in Fig. (5b). More homogeneous thin film island could be achieved by heating the substrate which was not carried out due to our limitation.

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