LASER ABLATION in LIQUID: FROM NANOCRYSTALS SYNTHESIS TO NANOSTRUCTURES FABRICATION

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ABSTRACT

Laser ablation in liquids (LAL) has been recognized to be an effective and general route to synthesize nanocrystals and fabricate nanostructures, especially, metastable nanostructures that prefer high temperature and high pressure. Therefore, we, in this talk, introduce recent developments in LAL for the synthesis and fabrication of novel nanostructures with metastable phases and shapes. There are four advantages of LAL over other conventional techniques of nanocrystals synthesis clearly as follows. (i) LAL is a chemically "simple and clean" synthesis, due to the process with reduced byproduct formation, simpler starting materials, no need for catalyst. (ii) There is an ambient conditions not extreme temperature and pressure in LAL, and a variety of metastable phases that may not be attainable by the same mild preparation methods could form upon LAL. (iii) The composition of the new phase of the synthesized nanocrystals may involve in both liquid and solid, which allows researchers to choose and combine interesting solid targets and liquid to fabricate nanocrystals and nanostructures of new compounds. (iv) Phase, size and shape, and pattern of the fabricated nanostructures can easily control by tuning laser parameters and applied assistances.

Key words: laser ablation in liquid, nanocrystals, nanostructures, synthesis, fabrication

INTRODUCTION

In recent decades, laser ablation of a solid target in a liquid environment has been widely used in preparation of nanomaterials and fabrication of nanostructures. Remarkably, there are many groups that pay attention to this issue in the world, and a large variety of nanomaterials such as metals, metallic alloys, semiconductors, polymers, and etc, have been synthesized using laser ablation of solid in liquid. Therefore, laser ablation in liquids (LAL) has been recognized to be an effective and general route to synthesize nanocrystals and fabricate nanostructures, especially, metastable nanostructures that prefer high temperature and high pressure [1].

Although nanomaterials investigations have been carried out for recent decades, researchers still face a fundamental challenge: how to control phase, size and shape of nanocrystals in the synthesis of nanomaterials. For this issue, we, in this talk, introduce recent developments in LAL for the synthesis and fabrication of novel nanostructures with metastable phases and shapes.

METHODS OF SAMPLE MANUFACTURING AND ANALYSIS

Basically, laser ablation in liquid (LAL) is divided into two kinds. One is the laser ablation of liquid in a gas or a liquid environment. In detail, laser ablates a liquid at the gas-liquid interface or the liquid-solid interface. In fact, the laser ablation of liquid has been intensely pursued in recent decades due to its enormous potential for technological applications such as the high-temperature chemical synthesis and laser-based material processing, in particular for medical applications when the laser irradiation is guarded inside the human body to ablate the "soft" tissue. Moreover, the laser ablation of liquids has provided a route to understand the interaction between laser and soft or organic matter with more complex structures. Another one is the laser ablation of solids in liquid environments, i.e., laser ablates a solid target at the liquid-solid interface. Therefore, we focus on the later and the relevant applications in synthesis of nanostructures in this Account. Note that, in most cases that be depicted above, the confining liquid is transparent for the irradiation wavelength.

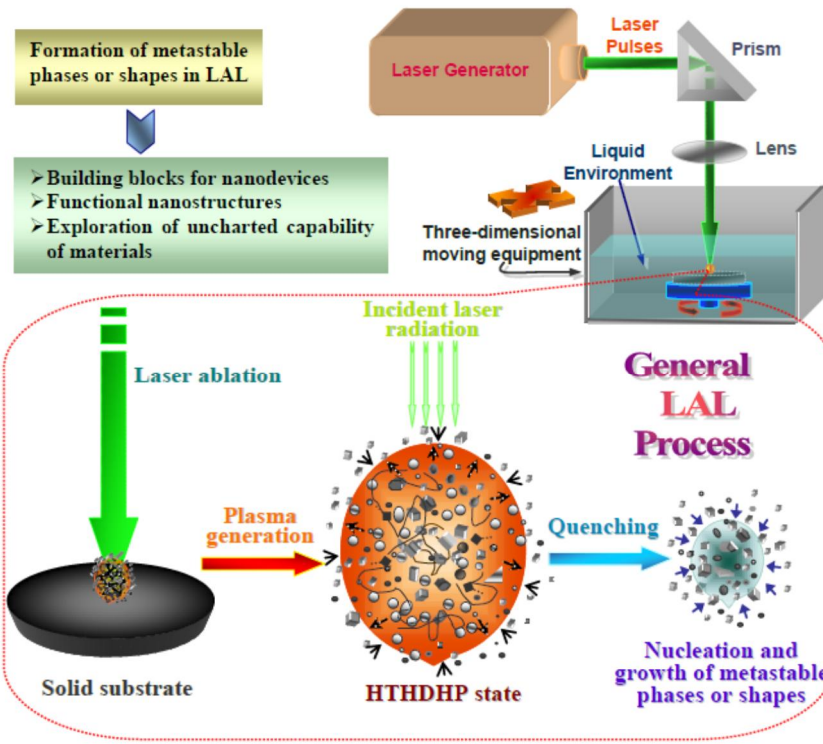

Fig. 1 – A scheme of LAL

Laser ablation of solid target in a liquid has actually opened a door toward to synthesize nanocrystals and nanostructures due to these advantages as follows. (i) LAL is a chemically "simple and clean" synthesis due to the process with reduced byproduct formation, simpler starting materials, no need for catalyst, etc. (ii) Under ambient conditions not extreme temperature and pressure, whereas a variety of metastable phases that may not be attainable in usual, can be formed by the same mild preparation methods. (iii) New phase formation involves in both liquid and solid upon LAL, which allows researchers to choose and combine interesting solid targets and liquid to fabricate nanocrystals and nanostructures of new compounds for purpose of fundamental research and potential applications. (iv) Phase, size and shape of the synthesized nanocrystals can be availably controlled by tuning laser parameters and applied assistances such as inorganic salts or electrical field upon LAL. For example, we synthesized micro- and nanocubes of silicon with zinc blender structure by adding inorganic salts upon LAL, and prepared micro- and nanocubes of GeO_2 by applied an electrical field into LAL. Additionally, we present further investigations involved in the new nanocarbons with C_8 and C_8-like structures synthesis and the nanopattern fabrication by pulsed-laser deposition in liquid.

CONCLUSIONS

laser ablation of a solid target in a confined liquid has been demonstrated an effective and general stragey for nanomanufacturing from phase, size and size controllably synthesis of nanocrystals to functional nanostructures fabrication, especially for the nanostructures with metastable phases and shapes.

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REFERENCES

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