DOI: 10.3969/j.issn.1003-501X.2017.02.005

Synthesis of nanoparticles by short pulsed laser ablation and its applications in nonlinear optics

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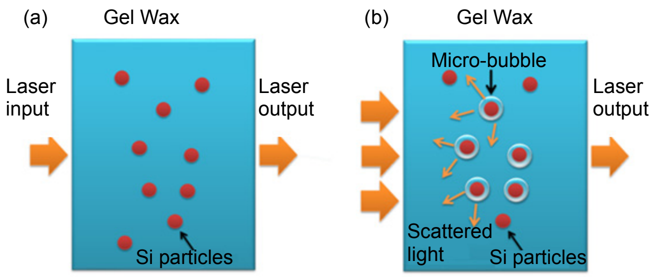

Schematic diagram for the nonlinear scattering (NS) mechanism. (a) At a low fluence, no significant influence on output light. (b) At a high fluence, melting of matrix generates localized micro-bubbles around each nanoparticle, incident light is nonlinearly scattered and output fluence is reduced.

Abstract: This paper mainly introduces the fabrication of nanoparticles by short pulsed laser ablation and its applications in the field of non-linear optics. With the characteristics of high purity, simple operation and wide applicability, the non-linear nanoparticles synthesized by short pulsed laser ablation show controllable size and size distribution, which has an unique role in non-linear optical materials. In order to further summarize this research area, this paper first introduces the optical non-linearity of the nanoparticles and the working principles of the pulsed lasers. Studies on non-linear optics illustrate various new optical phenomenas generated in the process of interaction between intense laser radiation and materials. Non-linear optical effects are derived from nonlinear polarization of molecules and materials. The physical mechanism of generating non-linear polarization mainly includes electron cloud distortion, induced acoustic motion, nuclear movement and optical Kerr effect, which result in anti-saturated absorption, self-focusing and two-photon absorption, and so on. Pulsed laser is produced by stimulated radiation with many advantages including high monochromaticity, high directivity, high strength and high coherence. The mechanism of interaction between pulsed laser and material is described as well, followed by analyzing the advantages of as-synthesized nanoparticles. The laser-materials interaction can lead to complex photo-thermal process, which makes the materials heated up, melt even on gasification, thus producing nanoparticles. So laser ablation has various advantages, such as simple setup, less operating steps, pollution-free process and applicable to most materials. What is more, the as-synthesized nanoparticles have high purity, small particle size and fairly uniform size distribution, and the size can be easily tuned by varying the laser processing parameters. The effects of processing parameters are also reviewed in detail. In general, the fabrication of nanoparticles is mainly affected by the following three factors: pulsed laser parameters (including intensity, pulse length, incidence angle and scanning speed, etc.), the performance of materials (absorption coefficient, chemical properties, melting point and crystallization temperature, etc.) and medium environment (vacuum, air and water, etc.). These parameters can be used to control the performance of nanoparticles. The current research status of various laser ablated nanoparticles is established for preparing different nanoparticles by pulsed laser ablation. The main types of nanoparticles include metal nanoparticles, metal oxide nanoparticles, carbon based nanoparticles and silica based nanoparticles. Researchers have taken these nanoparticles with excellent optical non-linearity highly into account and put the further research plans on the agenda. Synthesis of nanoparticles by pulsed laser ablation is significantly considered as an environmental-friendly and versatile method.

Keywords: optics; pulsed laser; nanoparticles; nonlinear optics

Citation: Zhou Rui, Li Fengping. Synthesis of nanoparticles by short pulsed laser ablation and its applications in nonlinear optics[J]. *Opto-Electronic Engineering,* 2017, **44**(2): 172–184.

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