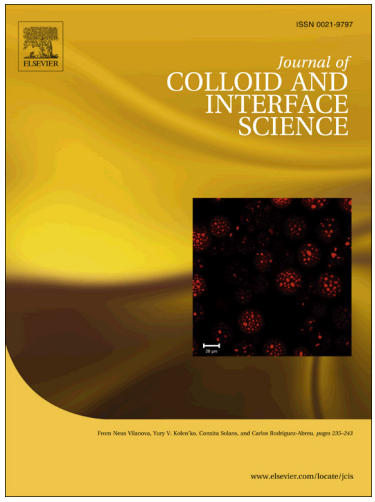


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# Origin of the nano-carbon allotropes in Pulsed Laser Ablation in Liquids synthesis

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**Abstract**

Carbon-based materials are of great technological and scientific interest in materials science. Pulsed Laser ablation in liquids (PLAL) is extensively used as a method to produce nanoparticles including nanodiamond and related materials. In this feature article, we will review the use of PLAL to tackle the challenges of synthesizing carbon-based nanostructures. Surprisingly, reported results have shown very poor reproducibility despite the use of similar experimental conditions. We use plasma spectroscopy and shadowgraph imaging to provide a picture of the thermodynamic properties, and then to better understand this apparent contradiction. Our study was carried out under traditional conditions which involve nanosecond laser, and radiant exposures from tens to thousands J/cm$^2$. Prompted by these results, the different scenarios reported in the literature are discussed including shockwave induced phase transition, growth in High Temperatures-High Pressures like conditions, and vapor phase chemistry.

*Keywords:* nanodiamond, nanoparticle, carbon allotropes, laser ablation, synthesis

## 1. Introduction

Over the past few decades, diamond and more generally carbon-based materials have become a successful candidate in a large number of applications. Very specific properties including non-toxicity, chemical stability, and rich surface chemistry largely contributed to the success of this material [1]. Indeed, diamond is a wide-bandgap semiconductor, in which impurities, dopants, $^{13}$C nuclei, and functional defects can lead to optically active centers [2] or long spin coherence time [3, 4]. In addition to these bulk features, nanodiamonds (ND) have become an attractive material for various applications [5, 6, 7]. Nanodiamonds have shown their reliability for in-vivo imaging [8, 9, 10], nanoscale imaging magnetometry with spins [11], biosensor [12], single photon source in quantum optics [13, 14], drug delivery [15, 16, 5, 7], data storage [17], high-speed temperature measurement [18], and catalysis [19]. Nanodiamonds and carbone-based materials have also captured broad interest in astrophysics since they have been observed in the interstellar medium [20, 21].

A history of the nanodiamond synthesis discovery can be found in ref. [22, 23]. Since the sixties, the synthesis by shock wave, detonation [24], or high pressure high temperature [25]

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