# Lonsdaleites and nano diamonds synthesis at room temperature in minutes

A team of scientists from the Australian National University, Sydney and RMIT university, Melbourne announced synthesizing nano sized diamonds and Lonsdaleites from the same sample and in the same anvil at room temperature and a pressure of 80 GPa. It is hoped that Lonsdaleite formation at lower temperature will herald a new era of technological applications of diamonds in future.

Lonsdaleite is an allotrope of Carbon like Diamond and graphite. Lonsadaleite has hexagonal crystal structure with tetrahedrally (SP3) bonded C atoms ( Fig.1) and theoretically expected to be harder than diamond ( 15.8 on mhos scale) . Graphite is having hexagonal structure, appears as a series of plates and comparatively soft material. Graphite and Lonsdaleite having a base structure of hexagonal, expected hardness of Lonsdaleite was attributed to Shear phenomenon while they are being formed. In 1967, Lonsdaleites were observed from the place of meteoritic impact. Naturally formed Lonsdaleites were soft compared to Diamonds. So efforts were focussed to synthesise Lonsdaleite in the laboratory by mimicking its formation conditions and the first sample was synthesised in 1967. However, it did not show the expected hardness.

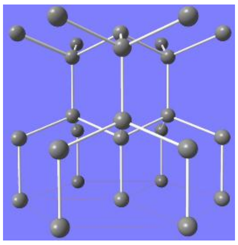

*Fig. 1: Schematic of arrangement of atoms in Lonsdaleite ( from Ref. 1)*

It is well established now that Diamonds are synthesized in the laboratory by two routes namely HPHT ( High Pressure and High Temperature) method and CVD ( Chemical vapour deposition) method. HPHT is by mimicking mother nature under very high temperature and pressure whereas CVD synthesis is carried out at relatively lower temperatures. Although diamond, graphite, microcrystalline carbon have all been produced regularly by CVD methods, synthesis of Lonsdaleite was reported only in the nineties of the last century.

The crystallographic arrangements of the diamond phases revealed that shear is the driving force for their formation and growth. In this method, starting material is non-crystalline glassy carbon. They packed sample chamber completely with glassy carbon sample and no pressure medium was used in order to increase the level of shear stress. However, pressure was created in the anvil cell by compressing. When the compression created 50 GPa pressure, sample started becoming transparent. Decompressing and compressing were repeated. Around 80 GPa, both nanocrystaline diamonds and the diamond like phase Lonsdaleites were formed together within bands with core-shell structure at room temperature. This study gives new understanding of how shear can lead to crystallization in material. A schematic from this land mark publication (Ref. 3) is copied as Fig.2 to show possible sequence of formation. This study also proposes that shear stress and the possible release of strain energy in center of thicker band trigger the formation of the diamond. The transformation is the result of intense radial plastic flow under compression in the diamond anvil cell, which lowers the energy by locking in favourable stacking of graphene sheets. This strain might have induced transformation of the graphitic planes of the precursor to hexagonal diamond.

During the various stages of the process microscopy techniques were used to examine the product. Particularly Raman spectroscopy. XRD and TEM were used to study the structure in different stages including final products.

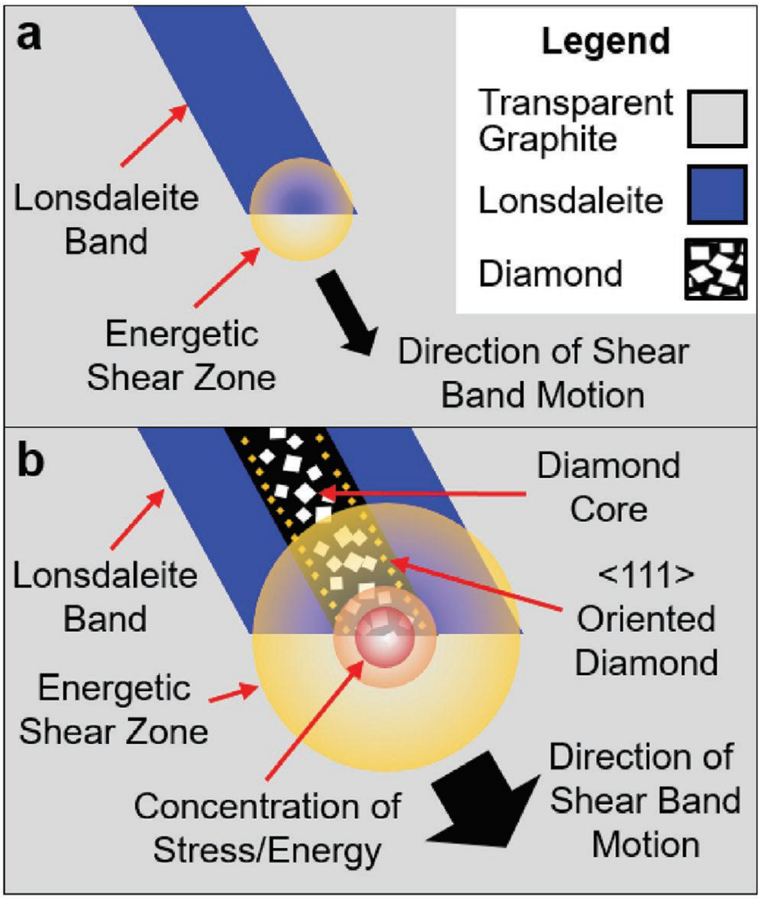


*Fig. 2 : Schematics of how shear stress in the samples could lead to bands of lonsdaleite and diamond. a) Cross-section through a thin band of lonsdaleite formed as a shear band moves through the transparent graphite matrix. b) Cross-section through a thicker band of lonsdaleite with a diamond core, the latter resulting from the concentration of stress and/or localized transient release of energy near the center of the band. The thin bands of lonsdaleite in (a) and the thicker lonsdaleite band with a diamond core in (b) correspond to those observed experimentally respectively.*

References:


1. Wikipedia
2. https://newatlas.co (Lonsdaleite was first identified in 1967 from the Canyon Diablo meteorite, where it occurs as microscopic crystals associated with diamond )
3. Dougal G. McCulloch et al, Investigation of Room Temperature Formation of the Ultra-Hard Nanocarbon Diamond and Lonsdaleite, Small, 204695 (2020) https://doi.org/10.1002/smll.202004695.