American Mineralogist, Volume 109, pages 1118–1128, 2024

Multi-wavelength Raman spectroscopy of natural nanostructured carbons

Sergey Isaenko[1,*], Tatyana Shumilova[1], Vladimir Bocharov[2], and Vasily Ulyashev[1]

[1]Institute of Geology, Federal Research Centre, Komi Science Centre of the Ural Branch of the Russian Academy of Sciences, Pervomayskaya 54, Syktyvkar 167982, Russia
[2]St. Petersburg State University, Ulyanovskaya 1, St. Petersburg, Peterhof, 198504, Russia

Abstract

There is an extensive range of carbon substances with poorly ordered structures that are not well understood. Yet they are important indicators of conditions of related geological processes. The carbon minerals include nanocrystalline graphite, natural analogs of glass-like carbon (GLC)—shungite and impact ultrahigh-pressure GLC, recently discovered ultranocrystalline diamond, as well as natural carbon nanocomposites of diamond, lonsdaleite, and graphite. Studying these natural carbon substances using a standard Raman approach with excitation by visible radiation may lead to a significant distortion of the understanding of their phase states. This paper presents in detail for the first time the spectral features of natural, poorly ordered, and multiphase sp^2-sp^3 carbon composites by multi-wave Raman spectroscopy using laser excitations from visible to ultraviolet light applied to natural low-ordered carbon substances—nanocrystalline graphite and shungite, nanocrystalline and ultranocrystalline diamond, and multiphase carbon aggregates. The carbon state resolution advantages of ultraviolet Raman spectroscopy for phase analysis of nanostructured and poorly ordered polycomponent carbon substances containing sp^2- and sp^3-carbons are presented. Raman spectroscopy with ultraviolet excitation can also be applied in the analysis of industrial carbon materials, such as glassy carbon and functional carbon nanocomposites, including ultranocrystalline diamond, lonsdaleite, and amorphous sp^3-carbon components.

Keywords: Raman spectroscopy, visible and ultraviolet excitation, natural nanostructured carbons