

METEORITIC NANODIAMOND: A MICRO-RAMAN SPECTROSCOPICAL OVERVIEW. *A. Gucsik¹, A. B. Verchovsky², U. Ott¹, E. Marosits¹, A. Karczewska³, M. Kozanecki⁴, M. Szurgo⁵, A.V. Fisenko⁶, L.F. Semenov⁶*
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Introduction: There are two hypotheses on the formation processes of the meteoritic nanodiamonds: (1) Chemical Vapor Deposition (CVD) and (2) Shock metamorphism. The purpose of this study is to investigate the crystalline background of the meteoritic nanodiamond from different meteorite separates and understand more about formation mechanism of these samples.

This method is not only of great help in elucidating crystal structures, but can also be used as a method of qualitative analysis (finger print), e.g., in determining the phases of small thin section areas without destroying them [1]. This technique is potentially useful for study of nanodiamonds.

Samples and Experimental Procedures: Details of separation procedures can be found in [2]. All spectra (except Allende) was obtained at Open University (UK) using 514 nm excitation system (10 sec exposure time for a single measurement with corrected background). *Allende*: Raman spectra were recorded using the confocal Raman micro-spectrometer T-64000 (Jobin-Yvon) equipped with the microscope BX-40 (Olympus) at Technical University of Lodz, Poland. Synthetic diamond powder was used as a reference material (Fig. 1a).

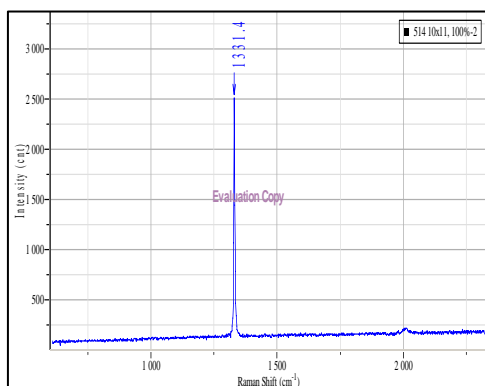
Results: Raman spectra of meteoritic nanodiamonds [3], and synthetic nanodiamonds are characterized by a significant peak at 1331 cm⁻¹. Mostly, this peak appears in very strong (vs) or strong (s) peak intensities, but, in some exceptional cases, it shows medium (m) as well as weak (w) spectral characters. There are observed additional peaks between 1393 and 1409 cm⁻¹, and at 1531, 1663, and 1856 cm⁻¹. Raman peak shifting (from higher to lower frequency modes) of the 1331 cm⁻¹ peak was detected in Allende (1326 cm⁻¹) (Fig. 2), Novo-Urei (1325 cm⁻¹) meteorites and synthetic detonation nanodiamond (1329 cm⁻¹) sample (Table 1). Some examples are shown in Figures 1-3.

Table 1. Peak positions and peak intensities of nanodiamonds from different origins.

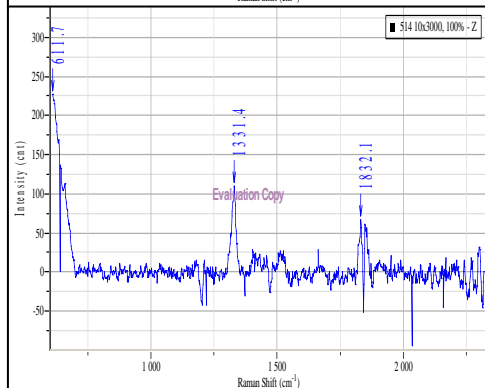
Nanodiamond	Peak Position (cm ⁻¹)	Peak Height
<i>Boriskino (coarse)</i>	1331.4	vs
	1409	s
	1531.9	vs
	1663.5	w
	1856.4	s
<i>Boriskino (coarse)</i>	1331.4	m
	1663.5	vw
	1832.1	m
<i>Boriskino (fine)</i>	1331.4	m
	1548.6	w
<i>Efremovka (fine)</i>	1331	m
	1403	m
	1531.9	m
	1663.5	m
	1856	s
<i>Efremovka (coarse)</i>	1331.4	w
	1393	m
	1531.9	vw
	1663.5	vw
	1856.4	w
	1924.4	w
<i>Efremovka (ED-8a)</i>	1331.4	m
	1663.5	w
	1832.1	m
<i>Novo-Urei (1)</i>	1331.4	vs
<i>Novo-Urei (2)</i>	1325.8	m
<i>Kaidun</i>	1331.4	s
	156.6	s
<i>UDD synthetic</i>	1331.4	m
	1600.4	m
<i>UDD synthetic detonation</i>	1329.7	s
	1630.4	s
<i>Terrestrial diamond</i>	1331.4	vs
<i>Allende (Lodz)</i>	1326	s
	1565	m
	1900	m

Discussion: Raman spectral properties of nanodiamond. The first order Raman band at 1331 cm^{-1} belongs to the C-C bonding (for carbon sp^3 -bonding) vibrational mode in nanodiamond. The D-band at 1350 cm^{-1} , and G-band at 1590 cm^{-1} are related to carbon sp^2 bonding graphitic structures, as well as 1150 cm^{-1} and 1450 cm^{-1} bands assigned to trans-polyacetylenes (chemical vapor deposited nanodiamond-CVD) [4].

a



b



c

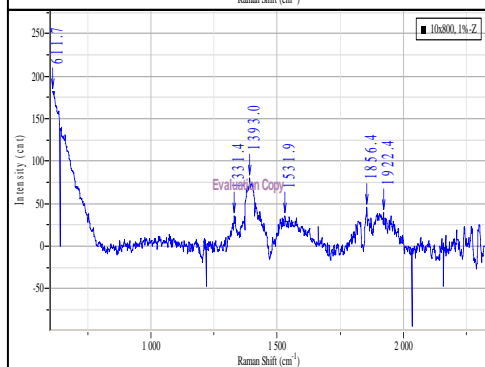


Figure 1. Raman spectra of synthetic nanodiamond powder as a reference material (a), and meteoritic nanodiamonds from Boriskino (b) and Efremovka (c).

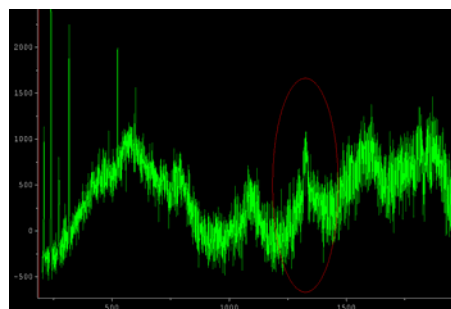


Figure 2. Raman spectrum of nanodiamond from Al-lende (obtained in Lodz, Poland) meteorite.

Raman peak broadening and shifting of nanodiamonds from different origin have been described by the following causes. (1) Diamond-like amorphous carbon, (2) neutron-flux, and (3) shock-induced origin. We observed that the UDD synthetic detonation diamond (grain size 4-7 nm), which was irradiated with ^{84}Kr ions (dose $\sim 10^{16}\text{ cm}^{-2}$), also shows peak shifts from 1331.4 (from natural kimberlitic line showing the same 1331 cm^{-1} as the other meteoritic nanodiamonds) to 1329 cm^{-1} (Fig.3).

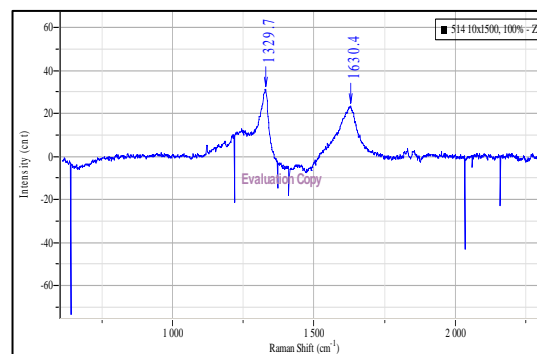


Figure 3. Raman spectrum of nanodiamond from the Kr-irradiated UDD sample.

Consequently, according to this Raman study, meteoritic nanodiamonds might be formed by both processes such as CVD and shock wave, but promoted by supernovae-induced shock wave front into the interstellar medium.

References: [1] Roberts S. and Beattie I. (1995) In *Microprobe Techniques in the Earth Sciences*, (eds. P.J. Potts, J.F.W. Bowles, S.J.B. Reed and M.R. Cave), Chapman and Hall, London, pp. 387-408. [2] Verchovsky A. B. et al, (2005) *LPS XXXVI*, Abstract #2285. [3] Hill et al. *MAPS*, 32, 713-718 [4] Karmenyan et al. (2007) *J. Phys.:Conf.Series*, 61, 513-517.