Name of the scientific solution / development/ methodology, tool, prototype
Novel Hybrid Ultrahard Material

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Problem Description

The essence of the problem of controlling structure and properties of diamond polycrystals is in the ability to produce a new generation of superhard materials that will combine the advantages of using both unique properties of CVD diamonds and diamond polycrystalline composites obtained by HPHT treatment on the basis of theoretical and experimental results obtained from the study of structural changes in the consolidation of diamond powders at high pressures and temperatures in the presence of additives activating the process of sintering,

The way of the problem solving

A strong covalent bond determines a high hardness of diamond, by which it penetrates into the most solid material without permanent deformation. Composite polycrystalline superhard materials obtained by HP-HT method are widely used in the manufacture of cutting and drilling tools that are the least energy-consuming. The diamond composite thermostable materials (DCTM), the dispersed structure of it was created in a strong framework of diamond-diamond bonding between particles, indicate a high strength of diamond particles retention in a composite matrix. In the process of cutting the surface, drill bits with the DCTM inserts penetrate into the rock, creating macro-and micro-cracks that contribute to its further destruction. The average Vickers hardness of DCTM is ~ 50 GPa, which is not enough for cutting especially of hard rocks. Polycrystalline CVD diamond obtained under strictly controlled conditions of activated carbon-hydrogen mixture have a hardness ~ 70 GPa and is synthesized in the form of plates larger than 50 mm and a thickness of several millimeters. At the same time CVD diamond have disadvantages - a tendency to generate high local stresses (up to 10 GPa) in the presence of inclusions of a nondiamond phase, structural and impurity defects, low coefficient of thermal expansion that mismatch with a substrate, the problem of obtaining the raw material of desired size because of the high hardness. During realization of works carried out by joint scientific projects of the NAS of Ukraine and the Russian Fund of basic Research in 2010 (project № 29-08-10), a new approach was tested, which is using the polycrystalline CVD diamond in the development of hybrid materials with high hardness at high pressure and at a lower temperature (~ 1500 K).

Basic publications

1. A.A. Shul’zhenko[a], E.E. Ashkinazi[b], A.N. Sokolov[a], V.G. Gargin[a], V.G. Ral’chenko[b],V.I. Konov[b], L.I. Aleksandrova[a], R.K. Bogdanov[a], A.P. Zakora[a], I.I. Vlasov[b], I.A. Artyukov[c], Yu.S.Petronyuk[d]

Novel Hybrid Ultrahard Material ISSN 1063-4576 Journal of Superhard Materials, 2010, Vol 5, pp 293-300.

2. Shul'zhenko A.A., Ashkinazi E.E., Sokolov A.N., et al., Novel Ultrahard Polycrystalline Composite Material, in *Porodorazrushayushchii I metaloobrabatyvayushchii instrument-tekhnika I tekhnologiya ego izgotovleniya I primeneniya* (Rock Destruction and Metal-Working Tools-Techniques and Technology of the Tool Production and Applications), Collect. Sci. Papers, Kiev: Bakul'ISM, Natl. Acad.Sci., 2009, issue 12, pp.143-153.

3. Shul'zhenko A.A., Nozhkina A.V., Bogdanov R.K., et.al., Wear Resistance and Thermostability of Diamond Polycrystalline Composite Materials, *ibid.,* pp. 237-242

4. Shul'zhenko A.A., Gargin V.G., Shishkin V.A., and Bochechka A.A., *Polikristalicheskie materially na osnove almaza* (Diamond-Based Polycrystalline Materials), Novikov N.V., Ed., Kiev: Naukova Dumka, 1989.

5. Shul'zhenko A.A. and Sokolov A.N., Synthesis of Special Superhard Materials, *Trudy Mezhdunar.Akademii "Kontenant"* (Proc. of the Contenant International Academy), Russian Division, vol. 2, Forming of Optical Surfaces, Moscow: Contenant, 2005, pp. 41-84.

6. Novikov N.V., Fedoseev D.V., Shul'zhenko, A.A., and Bogatyreva, G.P., *Sintez almazov* (Synthesis of Diamonds), Novikov, N.V., Ed., Kiev: Naukova Dumka, 1987.

7. *Shul'zhenko A.A., Nozhkina A.V., Gargin V.G., Bogdanov R.K., Zakora A.P., Bogatyreva, G.P., Petasyuk G.A., Loshak M.G., Aleksandrova L.I., Rusinova N.A., Gvyazdovskaya V.L., and Shamraeva V.S.* Comparative physico-mechanical characteristics of micron powders of synthetic and natural diamonds and their based-polycrystalline composite materials *of Superhard Materials, 2008, Vol.5, pp 7-15*

Innovative Aspects of the solution / development/ methodology, tool, prototype
Composite superhard materials based on polycrystalline diamond have been widely used in the manufacture of cutting and drilling tools (drill bits, bits, cutters). CVD diamond is close in properties to the most perfect diamond single crystals, and is increasingly used as a tool material for coating of cutting tool inserts. Variety of cutting and drilling tools, including drill bits, reamers, counter bores in the diamond coated CVD, etc., is now commercially available for machining non-ferrous metals, plastics and composite materials. However, there are a number of technology obstacles to obtaining an effective tools based on CVD diamond. First of all, it is typical for all diamond, and CVD diamond particularly, extremely low coefficient of thermal expansion, and secondly, anisotropy of polycrystalline diamonds due to columnar structure of crystals. These factors at the manufacturing by traditional methods of CVD diamond based tools and its use often lead to dangerous thermal stresses in the material, which result in its destruction. These obstacles were largely overcome when developing a new hybrid method of sintering ultrahard polycrystalline composite material reinforced with CVD diamond, whose perimeter is partially or completely under high pressure and temperature, covered with a shell of DCTM , with constraints of the diamond-diamond bonding between diamond grains in the composite component and the reinforcement, and the dispersion in the space.

Main advantages of the solution / development/ methodology, tool, prototype
Laboratory studies have established that the wear rate of the hybrid material with (DCTM + CVD diamond) at cutting granite of the XI-th category of drilling is the 5-14 times smaller than the elements from DCTM for rock crushing.

Financial and Economic Parameters
Documentation on the process of getting a new hybrid ultrahard material is available.

Investment Offer *(is not obligatory)*
The level of participation: establishment a joint venture

Current stage of development of the offered solution / development/ methodology, tool, prototype *(please, select)*
Stage of development is available for presentation.

Intellectual Property Rights *(please, select)*

1. Patent 89732 Ukraine, ***МПК С 04 В 35/00***. Superhard material / Shuezhenko O.O., Sokolov O.M., Gargin V.G., etc. – Published 25.02.10, Journal №4

(Patent RU 2413699 СГ МПК СО 423 (2009.01) Superhard Materials)

2. Patent for utility model 45291 Ukraine, ***МПК С 04 В 35/5831, С 04 В 35/80.*** Superhard material / Shulzhenko O.O., Sokolov O.M., Gargin V.G., etc. – Published 10.11.09, Journal №21

3. Patent for utility model 58629 ***МП С 04 В 35/583 (2011.01).*** Hybrid superhard material / Shulzhenko O.O., Bogdanov R.K., Gargin V.G., Sokolov O.M., Zakora A.P.

4. A registered trademark " *гибридный" (hybrid)*

Collaboration Details (
1. Technical co-operation. Type of collaboration sought; *more than one option can be selected)*

2. Joint venture agreement
Technology Key Words
CVD-diamond, polycrystalline, HPHT, hybrid material, ultrahard, thermo stability