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Shatrova, K.N., Chesnokova, I.A.

Synthesis and characterization of ultrafine tungsten carbide in a discharge plasma jet

National Research Tomsk Polytechnic University.

1. Introduction

Superhard tool materials play an important role in engineering and manufacturing. The characteristics of these materials are high hardness, strength, thermal stability, wear resistance, corrosion resistance. One of the best known superhard materials is tungsten carbide. It is used in the fabrication of various tools for metal cutting and rock drilling, for the manufacture of armor-piercing bullets and shells core.

At present there are a lot of methods for obtaining tungsten carbide. Tungsten carbide nanopowders are synthesized by electric discharge machining followed by annealing under nitrogen atmosphere [1]. Another method for obtaining tungsten carbide (WC) is a single step synthesis of nanoparticles directly from scheelite ore, which contains tungsten [2]. Tungsten carbide nano-particles are formed by carburizing tungsten/tungsten oxide/non-stoichiometric tungsten oxide particles obtained from a wire explosion process with multi walled carbon nano tubes [3].

Theoretical and experimental data analysis shows that one of the most promising ways is to obtain crystalline phases of nanodispersed tungsten carbide in the gas-phase system using carbon and tungsten powders as precursors. The required P, t-parameters can be obtained in the leading-edge shock wave of the supersonic pulsed carbon plasma jet impinging upon the chamber filled with gaseous nitrogen at the velocity up to 10 km/s.

2. Experimental

Experimentally the above described interaction is achieved with a pulse (up to 500 ms) high-current (about 10^5A) coaxial magneto-plasma accelerator (CMPA) with graphite electrodes [4, 5]. Initial mix of carbon and tungsten powders (total weight is 0,75 g with weight ratio W/C=2:1) is loaded into the zone where high-current Z-pinch arc discharge plasma structure accelerated in the coaxial system is formed. The accelerator is powered by a current pulse generator with a maximum stored energy of up to 360 kJ. In the experiment charging voltage is 3 kV and charging capacity is 6 mF that corresponds to 54 kJ of energy. Plasma is shot into the sealed reactor chamber filled with argon gas at normal conditions. The chamber is opened and the synthesized powder is collected after cooling and complete precipitation of suspended particles in the argon atmosphere. As a result, 0,485 g of dark gray powder product is obtained. The untreated synthesized material is examined with X-ray diffraction (XRD) using Shimadzu XRD7000 (CuK_{α}-radiation) diffractometer and high-resolution transmission electron microscopy (HRTEM) (JEOL JEM 2100F microscope).

3. Results

Figure 1 shows the X-ray diffraction pattern of the plasma-dynamic synthesis product. It is obvious that the obtained material consist of several ultrafine crystalline phases: tungsten W, tungsten carbides W_2C and WC_{1-x} and graphite gC. Phase analysis of the product was conducted with Powder-Cell and Powder Diffraction File PDF 4 programs. The main phase of the synthesized product is a cubic tungsten carbide WC_{1-x} (more than 95%).

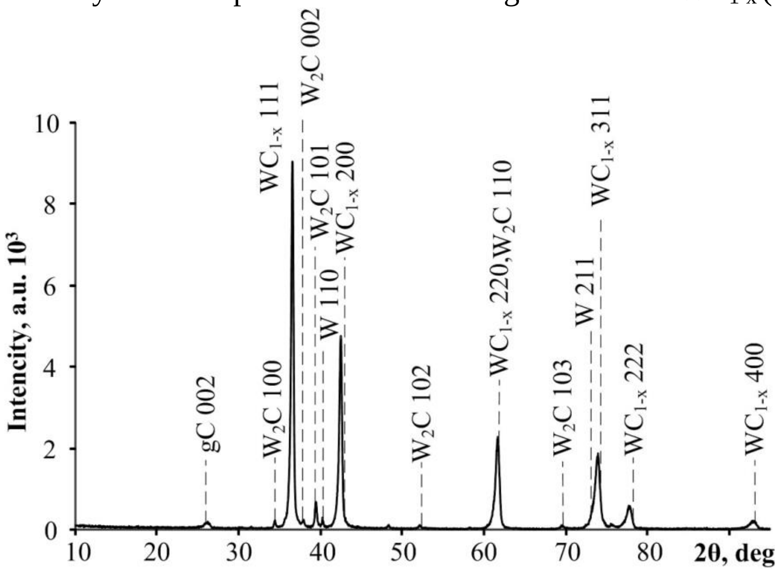

Fig. 1 (left). XRD pattern of the synthesized powder product.

Figure 2 shows the results of the high-resolution transmission electron microscopy of the product. The analysis of HRTEM images shows that the product consists of two types of objects (Fig. 2a). The first one is rounded particles sized up to 120 nm, which might be tungsten carbide phases. The second one is less dense objects, corresponding to nanosised carbon. In the selected area of the electron diffraction (SAED) image (Figure 2c) two diffuse rings (supposedly nano-sized graphite phase) and individual point reflex corresponding to interplanar spacings of tungsten carbide phases can be identified. Figure 2b is HRTEM image of a single tungsten carbide particle sized about 30 nm. The object has a rounded shape surrounded by a shell consisting of nano-sized graphite.

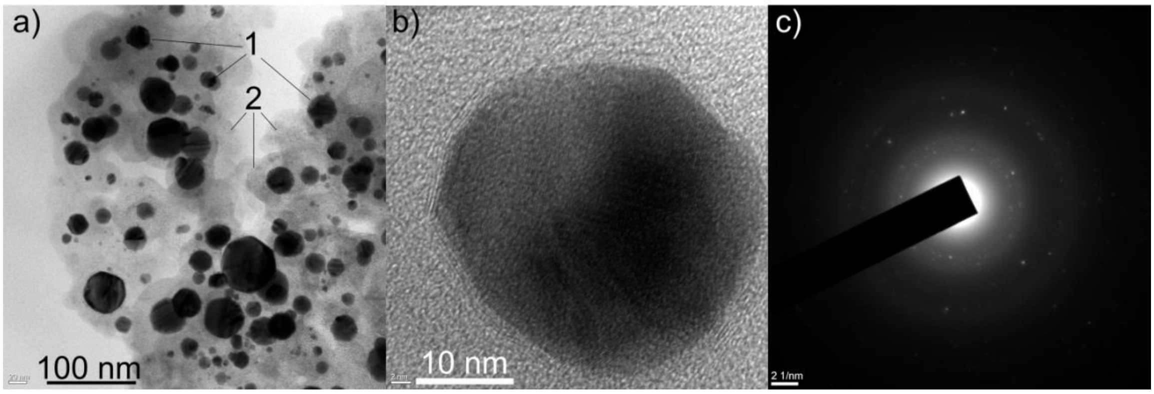

Fig. 2. HRTEM-images of the product: (a) Bright-field image; (b) Lattice image; (c) SAED.

Figure 3 shows the histogram of particle size distribution in the range from 10 nm to 120 nm. Only the first type of objects (tungsten carbide) is taken into account for the particle size distribution histogram. According to the histogram distribution is narrow enough and most particles are sided 10 to 40 nm. The peak of distribution is in the range from 10 nm to 20 nm.

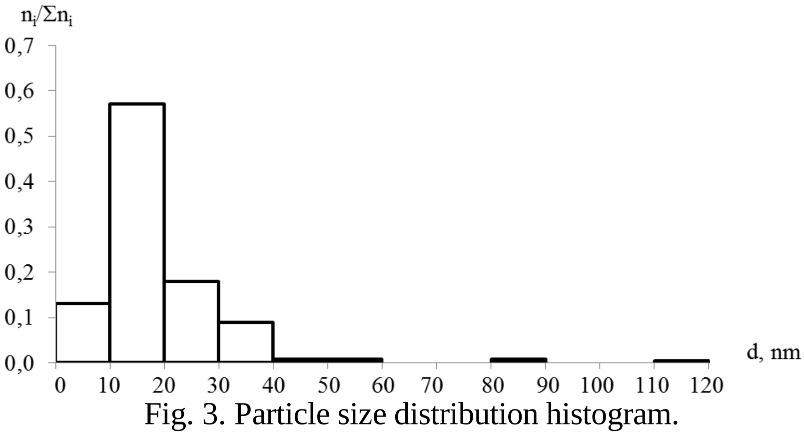

Fig. 3. Particle size distribution histogram.

4. Conclusion

Tungsten carbide is synthesied from the mix of pure tungsten and carbon black with plasmadynamic method using the system based on the coaxial magnetoplasma accelerator. The plasmadynamic synthesis product is composed of tungsten W, tungsten carbides W_2C and WC_{1-x} and graphite gC. The main phase of the synthesized product is cubic tungsten carbide WC_{1-x} (more than 95%). Particles of tungsten carbide WC_{1-x} are sized up to 120 nm.

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Научн. рук.: Сивков А.А., д.т.н., проф. каф. ЭПП.

Shoretz, J.J.

Witricity – Wireless Electricity

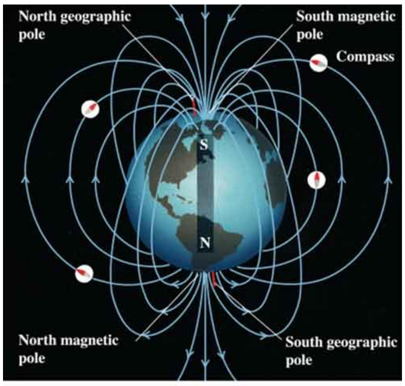
National Research Tomsk Polytechnic University.

What is WiTricity ?

- WiTricity is nothing but Wireless elecTricity.
- Transmission of electrical energy or power from one object to another without the use of wires is called as WiTricity.
- Because of WiTricity some of the devices won't require batteries to operate.

History of Wireless Power.

- In 1891, Nikola Tesla Proposed a method of Wireless Power Transmission. As it is in Radiative mode, most of the Power was wasted and has less efficiency.
- In 2005, Dave Gerding coined the term WiTricity which is being used today.



- Forgotten invention was reborn in 2007 by the MIT researchers.

Basics of WiTricity.

Electricity: The flow of electrons (current) through a conductor (like a wire), or charges through the atmosphere (like lightning).

Magnetism: A fundamental force of nature, which causes certain types of materials to attract or repel each other.

Electromagnetic Inductions: Is the production of voltage (induced current) across a conductor moving through a