Mechanochemical Methods of Nanocomposite Metal Powders Production

Oleg Lomovsky, Young Soon Kwon*

Institute of Solid State Chemistry and Mechanochemistry, Siberian Branch of RAS
Kutateladze str. 18, Novosibirsk, 630128, Russia
E-mail: lomov@solid.nsc.ru

* Research Center for Machine Parts and Materials Processing,
University of Ulsan
San-29, Moogu-2 Dong, Nam-Ku, Ulsan 680-749, Korea
E-mail: yskwon@mail.ulsan.ac.kr

The most effective mechanochemical tecnologies combine milling operation with physico-chemical transformations of solids.

Acceleration of treating bodies up to 100 m/s2 in modern high intensive mechanochemical reactors of planetary ball mill type reduces the transformation time to technologically appropriate values no more than tens of minutes. Different physical and chemical processes can be realized upon these conditions. Experimental results upon the main processes under intensive mechanical treatment are demonstrated:

1. Decrease of particle size and modification of surface. Generally the diminution of particle size less 1 mkm under mechanical treatment is not possible because of the achieving plasticity of particles materials. The problem is the most severe for plastic metals. Introduction of some substances reacting with the juvenal surface and preventing the particles welding is the successful approach.

Examples are provided of metal copper particles mechanical production in presence of fluorine containing organic substances, Cu - W - polytetrafluorethelene systems as materials with high elecroerosion resistance for sliding electrical contacts. Solid state modification of magnesium and magnesium – aluminum alloys via reaction with potassium bichromate is possible leading to 300-400 times higher corrosion resistance.

2. Formation of defects and changing of chemical properties.

Defect formation and amorphisation are the general results of intensive mechanical treatment of metal powder mixtures. Under treatment of Mg – Ni mixture nickel particles introduced into the bulk of magnesium forming the defect interface zone. During hydrogen treatment the formation of hydride nuclea is facilitated in interface zone, where the mobility of hydrogen and metal atoms is enhanced.

Quasicrystalline phases as Mg32(Zn,Al)49 can be formed under intensive mechanical treatment. Chemical and physical properties of quasicrystalline phases and the perspective utilization in thermoelectric material and hydrogen storage materials are under scope.

3. Formation of high reactive mechanocomposites.

Mechanocomposites are characterized by the little grains size and great interface surface. Utilization of mechanocomposites as precursors for thermal or another chemical reactions allow increase the time and energy costs for powder technologies and to achieve the monophase product content. The dependence of mechanocomposite reactivity has generally the maximum upon time of treatment as a result of formation of mechanocomposite and its mechanical transformation to final or subsidiary products.

TiBi2 synthesis in copper matrix is presented as an example. Self propagation high temperature reaction of mechanocomposite is used for synthesis of TiB2. Properties of material "nano-TiB2 in copper matrix" are discussed..

Nanocapsulated WC-graphite materials can be produced via the thermal treatment of mechanocomposite W – carbon.

4. Chemical reactions under mechanical treatment.

Mechanochemical reaction in Co – Al system with the formation of Co2Al5 intermetallic and the doping of system by Ti and Cr were under scope. Modern method of differental dissolution was used for the investigation of phase content of amorphous mixtures prepared via intensive mechanical treatment.

Phase formation is the first importance for the doping element state. Before the phase formation Cr solves as the solid solution in amorphous Co2Al5, after phase formation it solves separately. Alkaline leaching shows the Cr position in Co sublattice and possibility of formation of Co amorphous powders doped by Cr.

The review of modern high intensive mechanochemical activators for metal powder treatment is presented.