MECHANISMS OF MASS TRANSFER DURING MICROSTRUCTURE FORMATION IN MATERIALS ON THE BASIS OF REFRACTORY COMPOUNDS

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Generally, formation of microstructure in materials on the basis of refractory compounds under sintering is the result of several mass transfer mechanisms which proceed simultaneously or in series. They result in developing structural transformations such as phase, polytype and polymorphous ones as well as plastic deformation, recrystallization, recrystallization\\ through liquid and solid phases; formation, decomposition and ordering of solid solutions; chemical, eutectic, eutectoid and other reactions, which determine material structure formation. These transformations occur owing to different mass transfer mechanisms depending on the structural state of initial components, namely powder particle size and composition, crystalline structure, number and type of defects, and sintering conditions.

The present work is devoted to consideration of such problems of structure formation in powdered refractory materials as classification of different mass transfer mechanisms according to the nature of elementary mass transfer driver; short generalization of our and literature data on mass transfer mechanisms which determine the evolution of fundamental structural transformations, namely plastic deformation, recrystallization and polymorphic transformations that occur in the course of material microstructure formation at different stages of sintering such as the formation of interparticle and interphase contacts, intergrain boundaries as well as grain and subgrain structure; the effect of high pressure on mass transfer mechanisms, and the effect of particle size on mass transfer mechanisms under sintering.

In accordance with the nature of elementary carriers, mass transfer mechanisms in condensed media can be divided into four groups: i) atom-by-atom (diffusion type); ii) collective type; iii) collective-diffusion type, and iiii) crowd type.

Each of the first three groups includes several elementary mechanisms which differ in the nature of the driving force. Anomalous and nominal mechanisms, known in literature as effects, rules, transformations, *etc*. as well as memory effects are referred to a special separated group.

A plastic deformation under sintering of refractory materials proceeds by mechanisms known for metals: diffusion, lattice and rotation deformations, creeping and realization of lattice and structural superplasticity. A rotation deformation occurs in substances with different types of chemical bond, including a covalent one (diamond, dense BN phases and Si_3N_4).

Polytypic transitions in materials on the basis of refractory materials occur due to the following mechanisms: formation of packing defects, twins, antiphase boundaries, layers with different composition and/or structure as well as ordering of vacancies, etc.

High pressure affects mass transfer mechanisms at all of the stages of refractory material formation such as synthesis from initial materials, pretreatment of the powders including size reduction, mixing and deformation; cool compaction of green bodies, sintering, and post-treatment aimed at healing cracks, strengthening, etc.

Mechanisms of mass transfer under sintering of nanosized refractory materials powders differ from those in bulk materials at all of the sintering stages and consist, for example, in spontaneous densification up to a pore-free state, possible self-organization under sintering and aggregation of particles at room temperature. Herein collective grain growth proceeds with predominant participation of triple grain junction migration. Under sintering at high temperatures and pressure, there is observed a collective recrystallization, whereas in a coarser particle system marked deformation and a primary recrystallization take place.