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Sintering Behavior of Spherical Mono-Sized Tungsten Powder

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Abstract

Inert gas atomized mono-sized tungsten powders were cold pressed at 130 MPa and then sintered in the temperature range (0.52-0.73) T_m for different times under hydrogen atmosphere. The sintering kinetic was monitored by measuring shrinkage and density evolution and compared with commercially reduced tungsten powder.The formation of particle contacts, neck growth evolution as well as changes of the spherical particle habit were investigated by SEM studies

Compared to commercially reduced tungsten powders with relative sinter densities of ρ/ρ_{th} = 0.87…0.92, the achievable relative sinter density of spherical powders reached only 74% of the theoretical density. Besides the already known "saddle-shaped" neck profiles, crystallographic defined neck contours were found whose symmetry corresponds to the surface crystallography of a tetrakaidecahedron. The kinetic of the neck growth obeys the known cubic time law. The activation energy of the neck growth amounts to Q = 315 ± 44 kJ/mole. Simultaneously with the neck growth, there occurs an increasing transformation of the spherical particle habit into defined surface facets. The results will be discussed under consideration of the effects of direct sintering and the potassium bubble effect.

Keywords

Spherical tungsten powder, indirect sintering, neck growth, sintering mechanisms

1. Introduction

From an archaeological point of view, sintering technology is one of the oldest types of shaping technology, which can be traced back to more than 25 millenia in the mankind history [1]. If one ignores the historic fire-welded products of the ancient world, the platinum crucibles of W. H. Wollaston [2] and the Russian platinum rubles of P. G. Sobolevsky [3] can be regarded as the first industrial metallic sinter products of the modern age. However, it took almost further 100 years before W. D. Coolidge developed the PM-technology for "ductile" tungsten wire in the light sources industry [4]. In 1909, the so-called Coolidge process marked the industrial breakthrough of the PM and formed the basis of today's modern powder metallurgy not only for the refractory metals and cemented carbides but also for a multitude of further high performance materials.

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