

In-Situ Formation of WO₃ Nanowires as Well as Tungsten Nanoparticles by Oxidation-Reduction Mechanism

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Abstract

In this paper, an interesting approach for activating the solid-state sintering of tungsten powders was proposed. In this approach, WO₃ nanowires were formed on tungsten particles by addition of sub-micron particles as required oxygen source in powder mixture. High oxygen content of sub-micron particles acts as required oxygen source in formation of WO₃ nanowires. The microstructural studies exhibited that, reduction of WO₃ nanowires in hydrogen atmosphere led to formation of tungsten nanoparticles during sintering which can activate solid state sintering of compact.

Keywords: Solid state sintering; WO₃ nanowires; Tungsten nanoparticles

New Interesting Sintering Activation

It is suggested in current paper that WO₃ nanowires can be formed due to partial oxidation of tungsten particles and evaporation of resulted WO₃ at high temperature during sintering. It led to formation of needle like WO₃ nanowires with uniform distribution throughout compacts. These nanowires may be created based on nucleation and growth mechanism. By adequate controlling the thermal condition during sintering, linear growth of WO₃ nucleus will be predominated and then, linear growth of nanowires occurred. Subsequently, by interaction between WO₃ nanowires and hydrogen atmosphere, tungsten nanoparticles are formed on the micro-particles. Consequently, simple micro-particle powder mixture is replaced by a mixture containing uniformly distributed nanoparticles [1]. This in-situ formation of WO₃ nanowires following by in-situ formation of tungsten nanoparticles is illustrated in Figure 1. In summary, current proposed mechanism can be separated into some subsequently stages.

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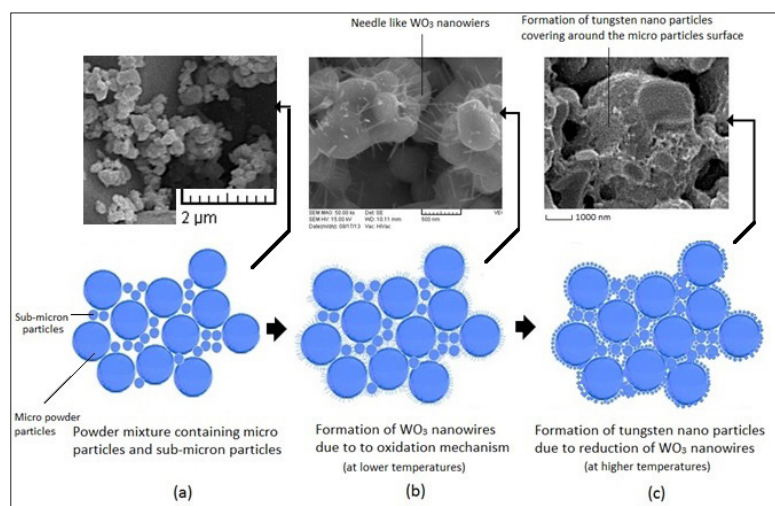


Figure 1: Different stages during in-situ formation of tungsten nanoparticles during sintering (a) formation of WO₃ nanowires due to nucleation of WO₃ vapors and subsequently linear growth, (b) hydrogen-reduction of needle like WO₃ nanowires and continues formation of nanoparticles, (c) micro-particles are completely covered by nanoparticles that activate sintering of compact remarkably.

On the other hand, when the sintering temperature continues to raise, reduction of WO_3 nanowires take place. Due to nanostructure of WO_3 , reduction of nanowires resulted into formation of tungsten nanoparticles around the former particles (Figure 1b & 1c) It is well known that the hydrogen reduction process has a great effect on the morphology of the reduced tungsten particles, especially on the diameter [2]. It resulted into homogenous distribution of nanoparticles in the whole of system. Tungsten nanoparticles formation on the micro particles exhibits activating sintering at low temperature owing to the size effects. Accordingly, the sintering

stress between nanoparticles and nanoparticle and micro-particle makes mass transport enhanced in the case of nanoparticle addition [3,4]. It led to enhanced densification in presence of nanoparticles.

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