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# Microwave Sintering of Refractory Metals/alloys: W, Mo, Re, W-Cu, W-Ni-Cu and W-Ni-Fe Alloys

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## ABSTRACT

Refractory metals and alloys are well known for their high mechanical properties which make them useful for wide range of high temperature applications. However, owing to the refractoriness of these metals and alloys, it is very difficult to consolidate them under moderate conditions. Conventional P/M processing is a viable sintering technique for these refractory metals. One of the constraints in conventional sintering is long residence time which results in undesirable microstructural coarsening. This problem gets further aggravated when using smaller (submicron and nano) precursor powder sizes. Furthermore, conventional heating is mostly radiative, which leads to non-uniform heating in large components. This review article describes recent research findings about how these refractory metals and alloys (W, Mo, Re, W-Cu, W-Ni-Cu and W-Ni-Fe) have been successfully consolidated using microwave sintering. A comparative study with conventional data has been made. In most cases, microwave sintering resulted in an overall reduction of sintering time of up to 80%. This sintering time reduction prevents grain growth substantially providing finer microstructure and as a result better mechanical properties have been observed.

**KEYWORDS:** Microwave sintering; Refractory metals/alloys; Microstructures

## INTRODUCTION

Refractory metals are known for their very high melting temperatures. Most refractory metals used for various applications are tungsten with fusion point of 3420°C, molybdenum of 2620°C and rhenium of 3180°C. Because of their high melting point, most refractory metals and alloys are consolidated through powder metallurgy (P/M) techniques, though for some specific applications mechanical alloying and infiltration technique are also employed. Most commonly, liquid phase sintering (LPS) is used for consolidating tungsten based alloys such as W-Cu, W-Ni-Cu and W-Ni-Fe compositions [Upadhyaya, 2001]. The LPS offers an advantage of relatively lower sintering temperature, enhanced densification, microstructural homogenization and near theoretical density.