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Densification of micro Molybdenum powders using Spark Plasma Sintering

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Abstract:

Molybdenum has a body-centered cubic structure with a melting point of 2610°C and a density of 10.22 g /cm^3 and presents a great potential to become an important refractory metal. The refractory properties of molybdenum reflect the high strength of inter-atomic bonding. This material has been used for high temperature applications in a variety of industries. In addition, the relatively low thermal neutron cross-section of Mo makes it suitable for nuclear applications. The unique combination of physical, chemical and mechanical properties of Mo makes it an ideal material for a variety of engineering applications where high temperature resistance, and ductility are key issues. Generally, powder metallurgy (P/M) has been used for the production of bulk Mo components. High sintering temperatures, in the range of 1800 - 2000°C, with long sintering times, are required for densification above 90% of the theoretical density for refractory metals.

Pure micro molybdenum powder was sintered using Spark Plasma Sintering under various temperatures, and holding times, under a pressure of 77 MPa and a heating rate at 700°C/min. After sintering, a carbide layer was observed at the surface. The carbide layer thickness, the relative density of the sample as well as the microhardness and the grain size of Mo were measured. The carbide thickness depends on time and temperature and it was found that the carbide layer grows in a parabolic manner, with activation energy of carbon diffusion in Mo equal to 34 Kcal/mol. The densification of Mo is controlled mainly by the sintering temperature and the holding time. The molybdenum powder was successfully consolidated by SPS in short times. A relative density of 100% is achieved at a sintering temperature of 1850°C and a holding time of 30 minutes. It was shown that the hardness decreases slightly with temperature and increases also slightly with time. It was found that the grain size increases with the sintering temperature and time.

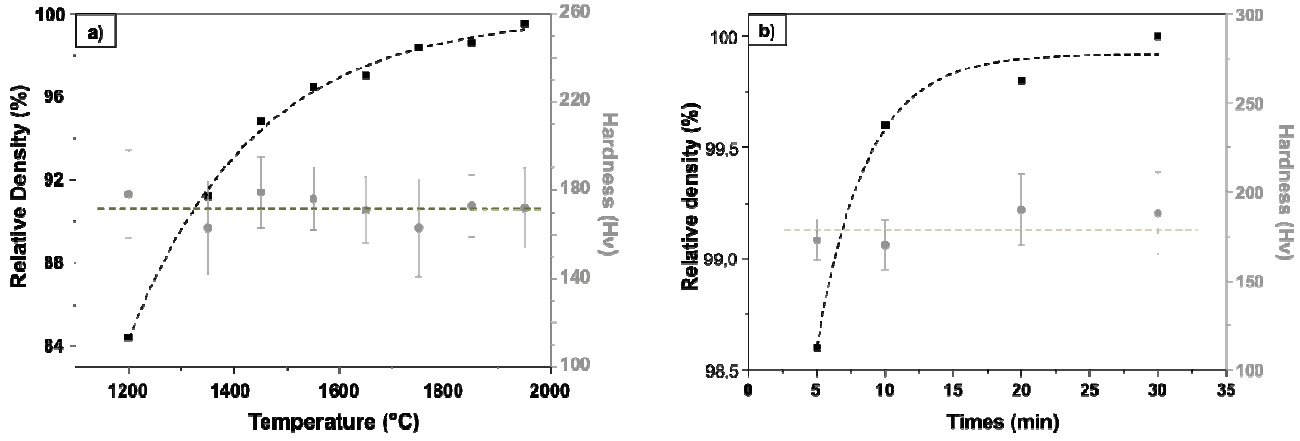

Figure 1: Evolution of relative density and hardness a) as function of sintering temperature and b) as function of holding time.