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Synthesising Carbo-Nitrides of Some d-Group Transition Metals Using a Solar Furnace at PSA

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Abstract. Carbo-nitride synthesis was undertaken using a solar furnace at PSA in flowing N_2/Ar gas mixture under total pressure 1 atm and processing temperature T = 1600°C for some d-group transition elements (Ti; Zr, V, Nb, Mo, W) starting from 1.5G/M (graphite/metal powder mixture with mole ratio 1.5:1) compact to ensure co-presence of free carbon with the reaction product. Clear X-ray diffraction (XRD) evidence of formation of carbo-nitride was detected for Ti (IVa group metal) showing higher N content in the carbo-nitride synthesised in N_2 gas environment at partial pressure $p(N_2)$ = 1 atm than that at $p(N_2)$ = 0.5 atm. For M = V and Nb (Va group metals), formation of mono-carbide MC single-phase was detected in the N_2 environment showing no evidence of formation of carbo-nitride in spite of presence of N_2 in the environment. For M = Mo and W (VIa group metals), formation of higher carbide, among several options of carbide phases, appeared to be promoted in the N_2 gas environment although, like in cases with the Va group metals, no evidence of dissolution of N into the reaction product was detected. As such, at T = 1600°C in N_2 gas environment up to $p(N_2)$ = 1 atm under concentrated solar beam, carbo-nitride formed from the 1.5G/M mixture only for IVa group metal (Ti) but not for Va and VIa group metals. Anyway, it seemed certain that N_2 gas affected somehow the reaction path between G and M to yield the carbide phase for M = V, Nb, Mo and W.

Introduction

Transition metal carbides, nitrides and carbo-nitrides are a very interesting class of compounds because they possess a unique combination of physical properties such as high melting points, high hardness, high electrical and thermal conductivities [1]. These properties have therefore attracted a great deal of interest for both technical applications and fundamental studies. The carbides, e.g., WC and TiC, the nitrides, e.g., TiN, and the carbo-nitrides, e.g., Ti(C,N) are widely used as hard constituents in metal matrix composites (hardmetals) and in the form of surface layers (coatings) on cutting tools. In addition, they have a high potential for a variety of other applications such as electrically conducting diffusion barriers in electronic devices; in coatings for solar applications as well as for corrosion protection [2,3]. For most hardmetal grades, the prime constituent is tungsten carbide (WC), while the binder metal is generally cobalt (Co), except in some corrosion applications where nickel (Ni) is used. Group IVa and Va metal carbides (titanium, zirconium,