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Low-temperature short-time nitriding of Va-group metals, V, Nb and Ta, in flowing NH₃ gas under irradiation of concentrated solar beam at PSA

J.C. Fernandes^a, F.A.C. Oliveira^b, L.G. Rosa^a, J. Rodríguez^c, I. Cañadas^c, T. Magalhães^b, N. Shohoji^{b,*}

^a Universidade de Lisboa, Instituto Superior Técnico, Departamento de Engenharia Mecânica, Av. Rovisco Pais, 1049-001 Lisboa, Portugal

^b LNEG - Laboratório Nacional de Energia e Geologia I.P., Laboratório de Energia, Estrada do Paço do Lumiar 22, 1649-038 Lisboa, Portugal

^c PSA - Plataforma Solar de Almería, CIEMAT - Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas, Apartado 22, E-04200 Tabernas (Almería), Spain

Abstract

Over the last two decades, we have been using concentrated solar beam as the reaction heat source for synthesizing carbides and nitrides of *d*-group transition elements in view of usage of ecological renewable energy source in place of conventional heat sources using electricity or gas. In recent works, nitriding of VIa-group metals (Cr, Mo, W) and Fe in stream of NH₃ gas with suppressed extent of dissociation (uncracked NH₃) was attempted under heating with concentrated solar beam. It was demonstrated that mono-nitride δ -MoN of Mo and sub-nitride ϵ -Fe₂N of Fe that are known to be impossible to synthesize in N₂ gas environment even at elevated N₂ gas partial pressure $p(N_2)$ up to 300 bar were successfully synthesized by the reactions of these metals in stream of NH₃ gas under heating with concentrated solar beam up to 800°C.

In the present work, nitriding of Va-group metals (V, Nb and Ta) was attempted in stream of NH₃ gas under irradiation of concentrated solar beam. After 90 min heating in uncracked NH₃ under concentrated solar beam up to 800°C, X-ray diffraction (XRD) characterization of the reaction products showed certain extent of nitriding progressed for all the specimens in spite of relatively low reaction temperature for short reaction duration.

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1. Introduction

Carbides and nitrides of *d*-group transition metals (Ti, Zr, Hf, V, Nb, Ta; Cr, Mo, W) are classified as refractory hard metals and they are with significant industrial importance [1–5]. In recent years, these compounds are also considered as functional materials (e.g., δ -MoN as superconductor [6] and carbides and nitrides as hydrogen-evolving electro-catalyst [7]).

Synthesis of these carbides and nitrides to be carried out at high temperature (typically > 1700 K) is highly energy-consuming process and thence, in view of saving conventional energy in form of electricity or gas, the authors have attempted a series of experiments to synthesize carbides using concentrated solar beam as the ecological renewable reaction heat source at PSA (Plataforma Solar de Almería, Tabernas, Spain) and at PROMES-CNRS (Laboratoire Procédés, Matériaux, Energie Solaire, Odeillo, France). The acquired results demonstrated that concentrated solar beam might be accepted as convenient reaction heat source for synthesizing refractory carbides.

* Corresponding author.

E-mail address: nobumitsu.shohoji@lneg.pt