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Author: J.P. Ramos T. Stora A.M.R. Senos P. Bowen

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Thermal stability of nanometric TiC-carbon composites: effects of carbon allotropes and Zr milling impurities

J.P. Ramos[a,b,*], T. Stora[b], A.M.R. Senos[c], P. Bowen[a,*]

[a]*Laboratory of Powder Technology, École polytechnique fédérale de Lausanne (EPFL), CH-1015 Lausanne, Switzerland*
[b]*European Organization for Nuclear Research (CERN), CH-1211 Genève 23, Switzerland*
[c]*Department of Materials and Ceramics Engineering, Universidade de Aveiro, CICECO, 3810-193 Aveiro, Portugal*

Abstract

In the ISOL (Isotope Separator OnLine) method a target at high temperatures (up to 2300 °C), is bombarded with high energy protons in order to produce isotopes through nuclear reactions which are simultaneously extracted from the target, ionized and delivered to physics experiments. Due to the enhanced isotope release properties of nanosized porous materials, titanium carbide-carbon porous nanocomposites have been developed at CERN and tested up to 1500 °C. In the interest of the ISOL application, in this study we extended the range of temperatures up to 1800 °C, to test the sintering hindering capabilities of different carbon allotropes. Carbon black was the most effective with the smallest TiC crystallite size: < 80 nm at 1800 °C. Additionally, using thermodynamic modelling, ex-situ X-ray powder diffraction and in-situ gas phase analysis, we show that there are interesting additional phase and lattice parameter changes due to the ZrO_2 impurities from the attrition milling.

Keywords: porous nanocomposites, high temperature applications, lattice parameters, solid solution, zirconium carbide-titanium carbide

1. Introduction

Radioactive ion beams are used all over the world for nuclear, atomic, solid state and biophysics studies. ISOLDE (Isotope Separator OnLine DEvice) at the European Organization for Nuclear Research - CERN, has developed beam technologies since its start in 1967, with almost 1000 isotope beams available from 74 chemical elements (from Z=2 to 92) [1]. As schematically represented in figure 1, ISOLDE uses the ISOL (Isotope Separator OnLine) method to produce radioactive isotopes where high energy particles, in this case protons at 1.4 GeV, are used to bombard a target to induce nuclear reactions which transmute a fraction of the target material atoms into different isotope elements of a lower mass number [2]. Such isotopes are then trapped in the bulk of the target material and have to diffuse to the surface, evaporate and diffuse through the material porosity to a transfer line (also called effusion) connected to an ion source. Here the isotopes are ionized and shaped into a beam which is then conducted to a mass separator where

*joao.pedro.ramos@cern.ch, paul.bowen@epfl.ch
URL: http://www.joaopedroramos.com (J.P. Ramos)