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Ariel University Center of Samaria

THE OPTIMIZATION OF COMPOSITION, STRUCTURE AND PROPERTIES OF METALS, OXIDES, COMPOSITES, NANO- AND AMORPHOUS MATERIALS

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PREFACE

The common Bi – National Workshop Russia – Israel is organized in accordance with the Agreement of Scientific Co-operation between the Russian and Israeli Academies of Sciences. The following stages of the Workshop were carried out during the last ten years:

In July, 2002 (Moscow and Ekaterinburg, Russia), in June - July, 2003 (Jerusalem and Tel-Aviv, Israel), in June, 2004 (Saint-Petersburg, Russia), in June, 2005 (Jerusalem, Tel-Aviv and Ariel, Israel), in July, 2006 (Novosibirsk and Irkutsk, Russia), in June 2007 (Jerusalem, Ramat-Gan, Ariel, Israel), in August 2008 (Perm, Russia), in June - July 2009 (Jerusalem, Tel-Aviv, Ariel, Israel), in July, 2010 (Belokurikha, Russia) and in June 2011 (Jerusalem, Ariel, Israel) Israeli and Russian scientists from different universities and research centers of science have visited the universities laboratories and centers and industrial concerns and plants.

The eleventh "Bi-National workshop Russia – Israel" will be held in Moscow and St.-Petersburg (Russia), July 8 - 18, 2012. The purpose of this meeting is to provide a forum in order to exchange information on the last researches and developments in modeling and simulation of physico-chemical processes and new materials development, solid state physics, inorganic chemistry etc. All of the papers scheduled for presentation are included in this book. In addition, the papers are also systematically placed on the Workshop homepage (general gate - http://www.ariel.ac.il/sites/conf/mmt).

The ten-year cooperation results induced an interest in both sides in expanding of collaboration themes. Support for continuing collaboration should be sought from the industry, and areas of practical application should be found for this purpose.

The Workshops were financed by the Israeli and Russian Academies of Science.

Co-chairmen of the Bi-national Organizing Committee:

Prof. Michael Zinigrad
Prof. Leopold Leontiev

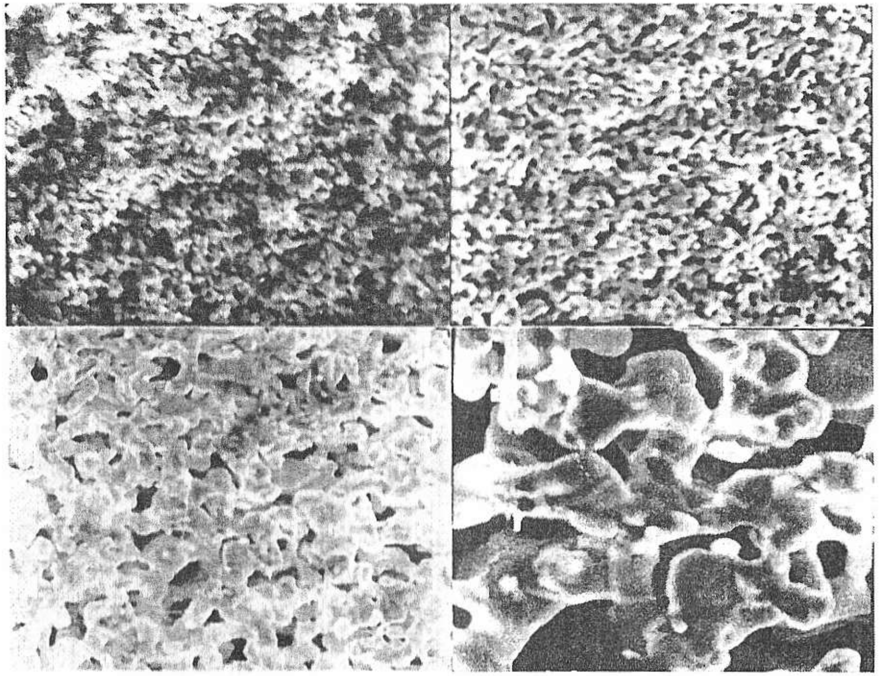

Fig 8. Foto of porous structure of sintered niobium samples from different temperature (1cm=1 μm)

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LOW-FREQUENCY OSCILLATION AFFECT TO TUNGSTEN AND VANADIUM CARBIDES INTERACTION WITH ALUMINIUM AND COPPER MELTS

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Abstract

Low-frequency oscillation method is applied to matrix metal melt with inducing to it carbides powder of Cu-VC, Al-VC and Al-WC systems to increase wettability of carbides by Al and Cu. It was found, that wettability in Al-VC and Al-WC systems is realized by chemical interaction of metal and carbide. As a result, V and W - aliminides and aluminium carbide Al_4C_3 are formed. New compounds are not formed in the Cu-VC systems. Complicated layer-volume strengthening structure composites are obtained. Its volume is saturated by nano- and submicro – particles of carbides and aluminides and its micro clusters. Top or bottom layers of ingots are saturated by its largest inclusions. Strengthening layers disposition is defined by the composite components density correlation.

Introduction

Industrial production feels escalating necessity for expansion of researches devoted to transition and high-melting carbides behavior for conditions of mechanic-chemical and thermal treatments. Information on high-melting carbides interaction with molten metals in extreme conditions (vibration, high pressure, etc.) is necessary for its application field specification and a choice of materials with necessary physical and chemical properties. It is known [1], that wetting angle of some carbides by Al (900°C) and Cu (1130°C) melts even after 15 mines aging is extremely high ($\Theta_{Al\text{-}VC}$ - 130, $\Theta_{Al\text{-}WC}$-135, $\Theta_{Cu\text{-}VC}$-140 degrees). This phenomena make problematic Al-VC, Cu-VC and Al-WC composites producing.

Researches of low-frequency oscillations influence (LFO) to interphase interaction between Al and Cu melts and vanadium and tungsten carbides powder are presented in this work. LFO treatment leads to wettability increase in these systems for the purpose to produce composites by liquid phase methods.

Research methods and materials

We have been synthesized vanadium carbide with V_8C_7 structure from metallic vanadium by its carbonization. The dendrite form of initial vanadium particles and its sizes (to 1mm) have thus remained the same. Carbide has been crushed then in spherical mill FRITSCH 7 till the average size CSD (coherent scattering domain) 139±55 nanometer. Carbide WC (TC-48-19-265-91) initial fraction 3-300 microns have crushed in planetary mill AGO-2C in the Ar media till the sizes CSD 14±3 nanometer.

Metal-carbide alloys were produced without low-frequency oscillation treatment (LFO) as well as with LFO influence to «metal melt - carbide powder » system, using laboratory installation [2]

Certification of initial and mechanically activated samples was carried out using XRD 700 and D8 ADVANCE diffractometers. Software packages DIFFRAC^{plus} and TOPAS have been used for processing and analysis diffraction patterns. Obtained alloys structure analysis has been carried out using optical microscope OLYMPUS-GX51 and electronic microscope Carl Zeiss EVO 40 XVP.

Experimental part

Two ways of vibration have been applied: vertical oscillation of crucible (LFOC) with molten metal and non-compacted powder of carbide; and vertical oscillations of the piston-radiator (LFOP), sunken in melt. Experimental results, obtained without LFO influence qualitatively coincide with data [1]. Absence of wettability and chemical interaction in systems Al-VC, Al-WC and Cu-VC has led to tearing away of carbides powders by Al and Cu melts. Ingots structure contains only individual fine allocation of strengthening phases. Vibration application completely changes character of interphase interaction. The received results are presented below.

System Al-VC. Vibration influence of LFOS to aluminium melt with non-compacted V_8C_7 powder was carried out at their masses ratio 10/1 during 15 mines at 900°C. Dendrite V_8C_7 structure is presented at

fig. 1 as a cross-section before (fig. 1 a) and after (fig. 1 b-c).

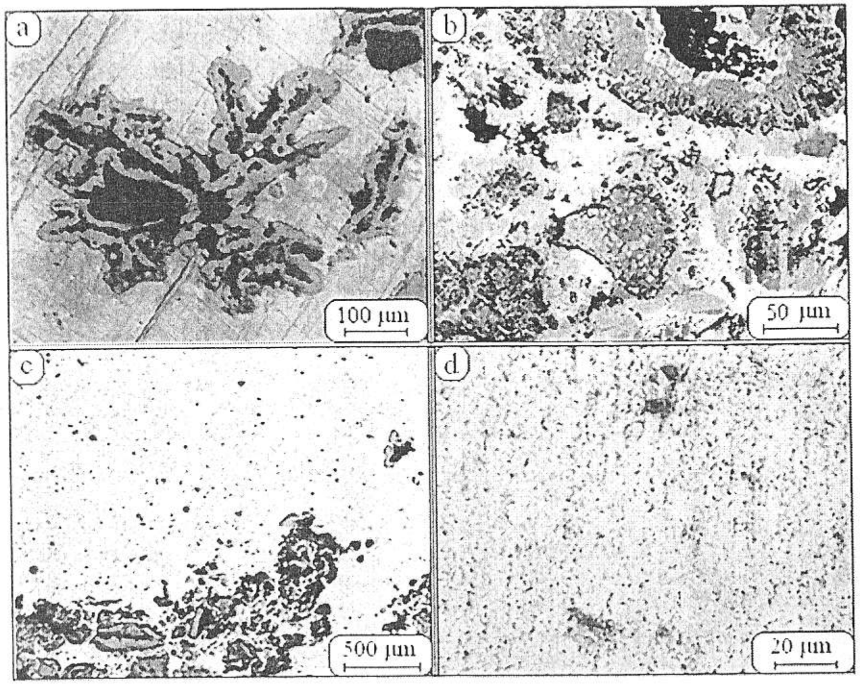

Fig. 1. Cross-section microstructure of V_8C_7 dendrite (a) and Al-V_8C_7 alloy (b-d): at ingot bottom (b), a boundary zone (c), ingot top (d)

At least 4 new phases was formed as a result of processing. These phases differ with reflective ability, relief and morphology. X-ray phase analysis has shown that chemical reactions have passed in Al-V_8C_7 system and almost all carbide has reacted with matrix metal forming aluminide vanadium, aluminium carbide and intermediate composition compounds AlV_2C:

$$Al + V_8C_7 \Rightarrow \alpha\text{-}Al + Al_3V + Al_4C_3 + AlV_2C + (VC)_{rest}$$

Gravitational stratification was observed in an alloy. Submicron particles (average size of particles about 0.5 microns) are mainly distributed in the top part of ingot as well as micron size (5-10 microns) particles, but in lesser degree. More large particles are concentrated in bottom part of ingot (fig. 1 c, d). Thus, complex layer-volumetric strengthening structure of composite alloy was generated. According to X-ray phase analysis, phase structure of the top and bottom parts of ingot are not different, and stratification has take place only under the dimensional factor.

System Al-WC. Alloys Al-33%WC are synthesize at LFO of crucible with aluminium melt and non- compacted WC powder at 1000°C and 680° C temperatures and 10 minutes of LFO influence time. As X-ray phase analysis of an alloy shows, vibration treatment at 1000°C initiated chemical reactions with formation of new phases - carbide of aluminium and tungsten aluminide: $Al+WC \Rightarrow \alpha\text{-}Al + Al_4W + Al_4C_3$. The microstructure of these alloys is presented on fig. 2.

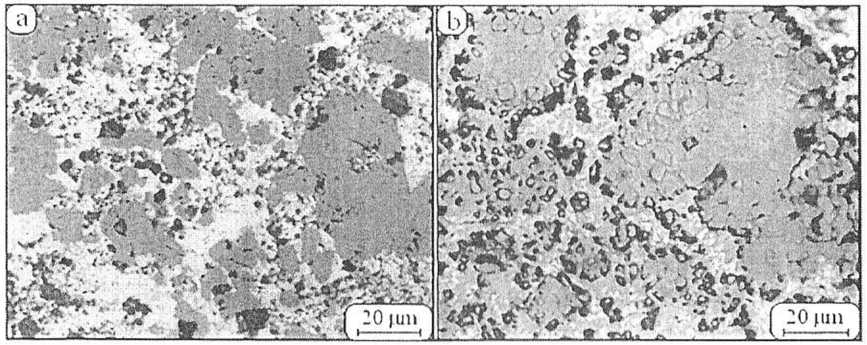

Fig. 2. Microstructure of Al-WC alloy synthesized at LFO influence at 1000°C (a) and 680°C (b)

It can be noted, that structure of alloys is non-uniform, and the sizes of new formations vary from 50 microns to 1μm and less. Besides the above temperature, the more homogeneously structure of large phases. Gravitational stratification on matrix metal enrichment degree by various phases is also observed on ingot height.

System Cu-VC. Alloy Cu-10%V_8C_7 is synthesized at LFO of crucible with copper melt and non-compacted carbide powder at their masses ratio 10/1 at 1180°C. The macrostructure, as well as in Al-V_8C_7 alloy, has gravitational stratification, but large particles of carbide are concentrated in the top part of ingots in this alloy. Disperse particles V_8C_7 ($\leq$ 1μm) also forms a suspension in all volume (fig. 3 a,b).

Interactions of components Cu-VC it is not observed. Thus, strengthening phase is V_8C_7 in the synthesized complicate-strengthened composite. Casted alloys Cu-V_8C_7 (1 %) then have been synthesized at LFOP (5 mines, 1200°C) with introduction initial and nano-size carbide V_8C_7 into the melt. Microstructure of last alloy is presented at fig.3 c,d.

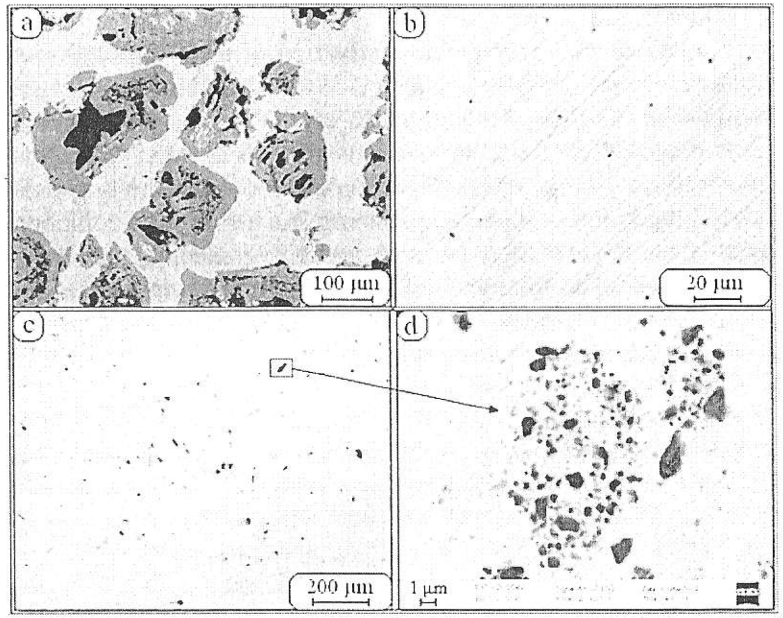

Fig. 3. Distribution of V_8C_7 particles in copper before (a-top, b - ingot bottom) and after (c,d) carbide crushing

Non-porous external interface boundaries in all alloys characterizes good wettability of carbide V_8C_7 the liquid copper, provided with LFO influence to system. However central parts close pores of the dendrite branches V_8C_7 remain (fig. 1a, b, 3a). After crushing of V_8C_7, the volume-strengthened composite with uniform enough distribution disperse (0,1-2 microns) V_8C_7 inclusions and small (5-20 microns) its conglomeration and non-porous carbide structure (fig. 3 c,d,) has been produced. Similar structure is observed also without preliminary V_8C_7 crushing. It can take place probably, due to more