Formation of Al2O3-reinforced Composites by Combustion Synthesis Involving Different Thermite Reactions

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ABSTRACT

Formation of Al2O3-reinforced borides (TiB2 and NbB2), silicides (Ti5Si3 and Nb5Si3), carbides (Ti3SiC2 and TiC), and intermetallics (TiAl) was conducted by self-propagating high-temperature synthesis (SHS) in argon. The synthesis reaction involves the elemental reaction and four different types of the thermite systems, including Al-TiO2, Al-SiO2, Al-B2O3, and Al-Nb2O5. Effects of Al2O3 content were studied on the propagation mode of combustion wave, flame-front velocity, reaction temperature, and product composition. On the other hand, different types of the thermite reactions were used for the synthesis of the same composite to understand the variation of Al2O3 content with type of the thermite system.

Keywords : Self-propagating High-temperature Synthesis ; Thermite reaction ; Al2O3 ; Composite

Table of Contents

REFERENCES

[1]機械工程手冊，“非金屬材料”，南圖書出版股份有限公司，2002。

[2]吳人傑，“複合材料”，文京開發出版股份有限公司，2004。

[3]郭衛紅，汪濟奎，“現代功能材料及其應用”，曉圓出版社，2006。

[4]K.Morsi,“Review:reaction synthesis processing of Ni-Al intermetallics materials,”Mater.Sci.Eng.,Vol.299,pp.1-15,2001.

[5]M.N.Mungole,R.Balasubramaniam,A.Ghosh,“Oxidation behavior of titanium aluminides of high niobium content,”Intermetallics,Vol.8, pp.717-720,2000.

[6]B.M.Warnes.,N.S.DuShane,J.E.Cockerill.,“Cyclic oxidation of diffusion aluminide coatings on coalt base super alloys,”Surface Coatings Technol.,Vol.148,pp.163-170,2001.

[7]V.Gauthier,B.F.Ernard,E.Gaffet,D.Vrel,M.Gailhanou,J.P. Larpin,“Investigation of the formation mechanism of nanostructured NbAl3 via MASHS reaction,”Intermetallics,Vol.10,pp.377-389,2002.

[8]C.Nishimura,C.T.Liu,“Reaction sintering of Ni3Al to near full density,”Scripta Metall.Mater.,Vol.26,pp.381-385,1992.

[9]Z.A.Munir,U.Anselmi-Tamburini,“Self-propagating exothermic reaction:the synthesis of high-temperature materials by combustion,” Mater.Sci.Rep.,Vol.3,pp.277-365,1989.

[10]P.Mossino,“Some aspects in self-propagating high-temperature synthesis,”Ceram.Int.,Vol.30,pp.311-332,2004.

[11]J.J.Moore,and H.J.Feng,“Combustion Synthesis of Advanced Materials:Part I. Reaction Parameters,”Prog.in Mater.Sci.,Vol.39, pp.243-273,1995.

[12]J.J.Moore,and H.J.Feng,“Combustion Synthesis of Advanced Materials:Part II. Classification,Applications and Modeling,”Prog. in Mater.Sci.,Vol.39,pp.275-316,1995.

[13]A.Makino, “ Fundamental Aspects of the Heterogeneous Flame in the Self-propagating High-temperature Synthesis (SHS) Process, ” Prog.in Energy Combust.Sci.,Vol.27,pp.1-74,2001.
[14]A.G.Merzhanov, “ History and recent development in SHS, ” Ceram. Int.,Vol.21,pp.371-379,1995.
[15]A.G.Merzhannov,and I.P.Borovinskaya, “ Self-Propagation High- Temperature Synthesis of Refractory Inorganic Compounds, ” Doklady Akademii Nauk USSK,Vol.204,No.2,pp.366-369,1972.
[16]L.L.Wang,Z.A.Munir,Y.M.Maximov, “ Review Thermite reactions:their utilization in the synthesis and processing of materials, ” J.Mater. Sci.,Vol.28,pp.3693-3708,1993.
[17]A.G.Merzhannov, “ Combustion and Plasma Synthesis of High-Temperature Materials, ” VCH,pp.1-53,1990.
[18]J.Mei,R.D.Halldearn,P.Xiao, “ Mechanisms of the aluminium-iron oxide thermite reaction, ” Scripta Mater.,Vol.41,pp.541-548,1999.
[19]H.X.Zhu,R.Abbaschian, “ In-situ processing of NiAl-alumina composites by thermite reaction, ” Mater.Sci.Eng.,Vol.299,pp.1-7,2000.
[20]A.S.Rogachev,V.N.Sanin,A.E.Sytschev,V.I.Yukhvid, “ Influence of gravity on self-propagating high-temperature thermite reaction:the case of Cu2O-Al and Cu2O-Cu-Al systems, ” Adv.Space Res.,Vol.29,pp. 505-510,2002.
[21]I.P.Borovinskaya,A.G.Merzhanov,N.P.Novikov,A.K.Filonenko, “ Gasless combustion of powder mixtures of the Transition metals with boron, ” Combust.Explos.Shock Waves,Vol.10,pp.2-10,1974.
[22]A.A.Zenin,A.G.Merzhanov,G.A.Nersisyan, “ The investigation of thermal wave structure in SHS processes on example boride synthesis, ” Dokl.Phys.Chem.,Vol.250,pp.83-87,1980.
[23]S.Otani,M.M.Korsukova,T.Mitsuhashi, “ Floating zone growth and high-temperature hardness of NbB2 and TaB2 single crystals, J. Crystal Growth,Vol.194,pp.430-433,1988.
[24]T.Tsuchida,T.Kakuta, “ Synthesis of NbC and NbB2 by MA-SHS in air process, ” J.Alloys Comp.,Vol.398,pp.67-73,2005.
[25]H.Takeya,A.Matsumoto,K.Hirata,Y.S.Sung,K.Togano, “ Superconducting phase in niobium diborides prepared by combustion synthesis, ” Physica:C,Vol.412-414,pp.111-114,2004.
[26]J.Yang,J.Wu,and W.Hua, “ Study on mechanical alloying and subsequent heat treatment of the Ti-Si system, ” Physica:B,Vol.279, pp.241-254,1999.
[27]I.J.Shon,H.C.kim,D.H.Rho,and Z.A.Munir, “ Simultaneous synthesis and densification of Ti5Si3 and Ti5Si3-20%ZrO2 composites by field-activated and pressure assisted combustion, ” Mater.Sci.Eng.A,Vol. 269,pp.129-135,1999.
[28]H.Inui,M.Moriwaki,N.Okamoto,and M.Yamaguchi, “ Plastic deformation of single crystals of TiSi2 with the C54 structure, ” Acta. Mater., Vol.51,pp.1409-1420,2003.
[29]J.D.Rigney,P.M.Singh,J.J.Lewandowski, “ Environmental effects on Ductile-phase toughening in Nb5Si3-Nb composites, ” J.Organomet. Chemie.,Vol.36,pp.36-41,1992.
[30]M.G.Mendiratta,J.J.Lewandowski,D.Dimiduk, “ Strength and ductile-phase toughening in the two-phase Nb/Nb5Si3 alloys, ” Metall.Trans. A.,Vol.22A,pp.1573-1583,1991.
[31]M.E.Schlesinger,H.Okamoto,A.B.Gokhale,R.Abbaschian, “ The NbSi (Niobium-Silicon) System, ” J.Phase Equilib.,Vol.14,pp.502-509,1993.
[32]M.W.Barsoum,T.El-Raghy, “ Synthesis and Characterization of a Remarkable Ceramic:Ti3SiC2, ” J.Am.Ceram.Soc.,Vol.79[7],pp.1953-1956, 1996.
[33]T.El-Raghy,M.W.Barsoum,A.Zavaliangos,S.R.Kalidindi, “ Processing and Mechanical Properties of Ti3SiC2: Ⅱ ,Effect of Grain Size and Deformation Temperature, ” J.Am.Ceram.Soc.,Vol.82[10],pp.2855-2860, 1999.
[34]J.Lis,Y.Miyamoto,R.Pampuch,K.Tanihata, “ Ti3SiC2-based materials prepared by HIP-SHS techniques, ” Mater.Lett.,Vol.22,pp.163-168,1995.
[35]F.Akhtara,S.J.Guo, “ Microstructure, mechanical and fretting wear properties of TiC-stainless steel composites, ” Mater.Character.,Vol. 59,pp.84-90,2008.
[36]F.H.Froes,C.Suryanarayana,D.Eliezer, “ Review synthesis, properties and applications of titanium aluminides, ” J.Mater.Sci., Vol.27,pp.5113-5140,1992.
[37]M.Yamaguchi,H.Inui,K.Ito, “ High-temperature structural intermetallics, ” Acta Mater.,Vol.48,pp.307-322,2000.
[38]劉顯光，許明發， “ 複合材料 ”， 全威圖書有限公司， 2001。
[39]C.L.Yeh,Y.G.Shen, “ Effects of TiC addition on formation of Ti3SiC2 by self-propagating high-temperature synthesis, ” J.Alloys Compd.,doi:10.1016/j.jallcom.2007.04.225.