

Symposium 12: Materials
for Extreme
Environments: Ultrahigh
Temperature Ceramics
(UHTCs) and Nano-
laminated Ternary
Carbides and Nitrides
(MAX Phases)

Wednesday, January 25, 2012
**Structural Stability under
Extreme Environments I**

8:00 AM-10:00 AM

Room: Coquina Salon F

Session Chair(s): Luc Vandeperre

8:00 AM

**(ICACC-S12-001-2012) Oxidation Mechanisms
in UHT and MAX Phase Ceramics (Invited)**

William Edward Lee*, Bai Cui, Emily Eakins,
Doni D Jayaseelan, Imperial College, United
Kingdom; Peter Brown, DSTL, United Kingdom

8:20 AM

**(ICACC-S12-002-2012) Testing SiC fiber-
reinforced ZrB₂ sharp component in
supersonic regime**

Laura Silvestroni*, Frédéric Monteverde, CNR-
ISTEC, Italy; Roberto Savino, DIAS - University
of Naples, Italy; Diletta Sciti, CNR-ISTEC, Italy

8:40 AM

**(ICACC-S12-003-2012) High-Temperature
Oxidation Testing of UHTC Composites**

Anish Paul*, Saranya Venugopal, Jon Binner,

Bala Vaidhyanathan, Loughborough University,
United Kingdom; Peter Brown, Andrew
Heaton, Dstl, United Kingdom

9:00 AM

**(ICACC-S12-004-2012) Protection against
oxidation, by CVD or SPS coatings of Hafnium
Carbide and Silicon Carbide, on Carbon/
Carbon composites.**

Alexandre Allemand*, CEA, France; Yann Le
Petitcorps, Olivier Szwedek, Universite de
BORDEAUX, France; Nicolas Teneze, Patrick
David, CEA, France

9:20 AM

**(ICACC-S12-005-2012) Experimental methods
for reliable oxidation measurements of ultra-
high temperature ceramics up to 1600°C**

Melia Miller-Oana*, Luke S Walker, William R
Pinc, Erica L Corral, University of Arizona,
United States

9:40 AM

Break

**Structural Stability under
Extreme Environments II
and Novel Processing
Methods I**

10:00 AM-12:00 PM

Room: Coquina Salon F

Session Chair(s): Martin Magnuson, William
Lee

10:00 AM

**(ICACC-S12-006-2012) Charged particle
irradiation of (Ti,Zr)₃(Si,Al)C₂ : structural
disorder and thermal diffusivity**

Marion Le Flem*, Xingmin Liu, Sylvie Doriot,
Théodore Cozzika, CEA Saclay, France; Denis
Rochais, CEA Le Ripault, France; Isabelle

Monnet, CIMAP, France

10:20 AM

(ICACC-S12-007-2012) Behaviour under ion-irradiation of Cr₂GeC and Cr₂AlC

Matthieu Bugnet, Thierry Cabioch*, Vincent Mauchamp, Michel Jaouen, University of Poitiers, France

10:40 AM

(ICACC-S12-008-2012) High Strain Rate Deformation Behavior of Nanolaminated Titanium Aluminum Carbide

Sandeep Abotula, University of Rhode Island, United States; Sandip Basu, Miladin Radovic*, Texas A&M University, United States; Arun Shukla, University of Rhode Island, United States

11:00 AM

(ICACC-S12-009-2012) Growth of Ti₃SiC₂ single crystals (Invited)

Didier Chaussende*, Thierry Ouisse, CNRS - Grenoble INP, France

11:20 AM

(ICACC-S12-010-2012) Growth and electrical transport properties of Cr₂GeC thin films

Per Eklund*, Linkoping University, Sweden; Matthieu Bugnet, Vincent Mauchamp, Sylvain Dubois, Christophe Tromas, Université de Poitiers, France; Jens Jensen, Linkoping University, Sweden; Luc Piraux, Loik Gence, Université catholique de Louvain, Belgium; Michel Jaouen, Thierry Cabioch, Université de Poitiers, France

11:40 AM

(ICACC-S12-011-2012) MAX phase formation by intercalation upon annealing of TiC_x/Al (0.4 ≤ x ≤ 1) bilayer thin films

Jochen Schneider*, Ahmed Abdulkadhim, Denis Music, Tetsuya Takahashi, Frans Munnik, RWTH Aachen University, Germany

New Methods for Joining

1:30 PM-3:30 PM

Room: Coquina Salon F

Session Chair(s): Erica Corral, Guo-Jun Zhang

1:30 PM

(ICACC-S12-012-2012) Joining of Ultrarefractory Carbides

Diletta Sciti*, Laura Silvestroni, ISTECCNR, Italy; Andreas Glaeser, University of California, United States; Laura Esposito, ISTECCNR, Italy

1:50 PM

(ICACC-S12-013-2012) Spark Plasma Joining of Ultra-High Temperature Ceramics with Zirconium-Boron Filler Materials

William Pinc*, Luke S Walker, University of Arizona, United States; Zachary Wing, Advanced Ceramics Manufacturing, United States; Erica L Corral, University of Arizona, United States

2:10 PM

(ICACC-S12-014-2012) Effect of Current Density on the In Situ Temperature Measurement During Rapid Joining of ZrB₂-SiC Using a Spark Plasma Sintering Furnace

William Pinc*, Luke Walker, University of Arizona, United States; Zachary Wing, Advanced Ceramics Manufacturing, United States; Erica L Corral, University of Arizona, United States

2:30 PM

(ICACC-S12-015-2012) Effect of Carbon Additions on the Thermal and Electrical Properties of Hot Pressed ZrB₂

Gregory Harrington*, Greg E Hilmas, William G Fahrenholtz, Missouri S&T, United States

2:50 PM

(ICACC-S12-016-2012) Thermal Properties of ZrB₂-TiB₂ Solid Solutions

Matthew Thompson*, William G Fahrenholtz, Greg Hilmas, Missouri University of Science and Technology, United States

3:10 PM

(ICACC-S12-017-2012) Lattice thermal conductivity of ultra high temperature ceramics (UHTC) ZrB₂ and HfB₂ from atomistic simulations

John W Lawson*, NASA Ames Research Center, United States; Murray S Daw, Clemson University, United States; Charles W Bauschlicher, NASA Ames Research Center, United States

Novel Processing Methods

II

3:30 PM-6:10 PM

Room: Coquina Salon F

Session Chair(s): Marion Le Flem, Miladin Radovic

3:30 PM

(ICACC-S12-018-2012) Synthesis and crystal growth of MAX-phases from molten metals (Invited)

Harald Hillebrecht*, D. Kotzott, H. Leuckeroth, M. Kleczek, University of Freiburg, Germany

3:50 PM

(ICACC-S12-019-2012) Hysteresis in MAX phases (Invited)

William J Clegg*, Caroline Humphrey, University of Cambridge, United Kingdom; Finn Giuliani, Imperial College, United Kingdom

4:10 PM

(ICACC-S12-020-2012) Processing and Mechanical Properties of Ti₂AlC Reinforced with Alumina Fibers

Kwonguk Jeon, Sandip Basu, Francesco Schaff, Texas A&M University, United States; Michel W Barsoum, Drexel University, United States;

Miladin Radovic*, Texas A&M University, United States

4:30 PM

(ICACC-S12-021-2012) Crystallisation and annealing of Cr₂AlC: a Raman investigation

Vladimir Vishnyakov*, Piotr Dobrosz, John Colligon, Manchester Metropolitan University, United Kingdom

4:50 PM

(ICACC-S12-022-2012) Effect of lattice anisotropy on plasticity mechanisms in Ti₂AlN studied by in-situ compression of micro-pillars under synchrotron micro-beam

Ludovic Thilly*, Joan J. Roa, Antoine Guitton, Patrick Villechaise, Christophe Tromas, Anne Joulain, University of Poitiers, France; Cécile Marichal, Steven Van Petegem, Helena Van Swygenhoven, Paul Scherrer Institut, Switzerland

5:10 PM

(ICACC-S12-023-2012) Effects of Porosity and Pore Size on Room Temperature Thermal Conductivity and Mechanical Properties of Porous Ti₂AlC

Liangfa Hu*, Sandip Basu, Rogelio Benitez, Ibrahim Karaman, Miladin Radovic, Texas A&M University, United States

5:30 PM

(ICACC-S12-024-2012) Properties of Hot-Pressed Ti₂AlC Obtained by SHS Process

Leszek Chlubny*, Jerzy Lis, AGH-University of Science and Technology, Poland

5:50 PM

(ICACC-S12-025-2012) Deposition of MAX-phases coating by cold spray

Silvano Rech, Andrea Trentin, Alessandro Patelli, Alessandro Surpi, Simone Vezzù*, CIVEN, Italy; Per Eklund, Jenny Frodelius, Lars

Hultman, Linköping University, Sweden; Jack Glor, Sandvik AB, Sweden

Symposium 12: Poster Session

5:00 PM-7:30 PM

Room: Exhibition Hall, Ocean Center

(ICACC-S12-P120-2012) Thermal expansion and structural parameters of $\text{Cr}_2(\text{Al}_x\text{Ge}_{1-x})\text{C}$ studied by X-ray diffraction

Thierry Cabioch*, University of Poitiers, France; Per Eklund, Linköping University, Sweden

(ICACC-S12-P121-2012) Ultrarefractory carbides for applications in Concentrating Solar Power systems

Diletta Sciti*, Laura Silvestroni, ISTE-CNR, Italy; Jean Louis Sans, Ludovic Charpentier, Marianne Balat-Pichelin, Luca Mercatelli, CNRS, France; Elisa Sani, CNR, Italy

(ICACC-S12-P122-2012) Effect of Oxy-acetylene Torch Test Flame Conditions on the Ablation Resistance of Ultra-High Temperature Ceramic Composites at Elevated Temperatures

Mario Alberto Valdez*, William R Pinc, Luke S Walker, Erica L Corral, University of Arizona, United States

(ICACC-S12-P123-2012) Mechanical Properties & Residual Thermal Stresses of Spark Plasma Sintered $\text{ZrB}_2\text{-SiC}$ Composites

Richard Stadelmann*, Nina Orlovskaya, University of Central Florida, United States; Vincenzo Sglavo, University of Trento, Italy

(ICACC-S12-P124-2012) Oxidation-resistant $\text{ZrB}_2\text{-SiC}$ composites

Ali Goodarzi*, Amirkabir University of Tech., Iran, Islamic Republic of; Hailey Taylor,

Imperial College London, United Kingdom

(ICACC-S12-P125-2012) Tensile Creep of Coarse-Grained Ti_2AlC in the 900-1150 °C Temperature Range

Darin Joseph Tallman*, Michael Abdelmalak, Michel Barsoum, Drexel University, United States

(ICACC-S12-P126-2012) Study of NiTi-MAX Phase Composites Prepared via Spark Plasma Sintering

Ankush Kothalkar*, Liangfa Hu, Sandip Basu, Francesco Schaff, Ibrahim Karaman, Miladin Radovic, Texas A&M University, United States

(ICACC-S12-P127-2012) Interfacial Study between Ti_3SiC_2 and NiTi Shape Memory Alloy via Diffusion Bonding

Ankush Kothalkar*, Sandip Basu, Patrick Mahaffey, Miladin Radovic, Ibrahim Karaman, Texas A&M University, United States

(ICACC-S12-P128-2012) Thermal atomic displacements in select MAX phases through first-principles phonon calculations

Nina Lane*, Drexel University, United States; A. Togo, Kyoto University, Japan; L. Chaput, Université de Nancy, France; G. Hug, ONERA-CNRS, France; M. Barsoum, Drexel University, United States

(ICACC-S12-P129-2012) Microstructural characterization and compression properties of $\text{TiC}_0.61/\text{Cu}(\text{Al})$ composites synthesized from Cu and Ti_3AlC_2 powders

Zhenying Huang, School of Mechanical and Electronic Control Engineering, China; Véronique Gauthier-Brunet, Joël Bonneville, Institut PPRIME, France; Hongxiang Zhai, School of Mechanical and Electronic Control Engineering, China; Anne Joulain, Sylvain Dubois*, Institut PPRIME, France

(ICACC-S12-P130-2012) Structure and properties of oxide coatings on Al-Cu and Al-Mg alloys

Alexander D Pogrebnjak*, Sumy State University, Ukraine; Manarbek K Kylyshkanov, Serikbayev East Kazakhstan state technical University, Kazakhstan; Yurii N Tyurin, The E.O.Paton Electric Welding Institute, Ukraine; Alisa S Kaverina, Ivan V Yakushchenko, Sumy State University, Ukraine

**Thursday, January 26, 2012
Processing, Structure and Property Relationships**

8:00 AM-10:00 AM

Room: Coquina Salon F

Session Chair(s): Yutaka Kagawa, James Zimmermann

8:00 AM

(ICACC-S12-026-2012) Mechanical Behavior of ZrB₂/SiC Particulate Composites Produced with varying SiC Particle Sizes

Jeremy Watts*, Greg Hilmas, William G Fahrenholtz, Missouri University of S & T, United States

8:20 AM

(ICACC-S12-027-2012) TaB₂-based ceramics: microstructure, mechanical properties and oxidation resistance

Laura Silvestroni*, Stefano Guicciardi, Cesare Melandri, Diletta Sciti, CNR-ISTEC, Italy

8:40 AM

(ICACC-S12-028-2012) Densification Behavior and Mechanical Properties of ZrB₂ Processed Using Spark Plasma Sintering

David Pham*, William R Pinc, Luke S Walker, Erica L Corral, University of Arizona, United States

9:00 AM

(ICACC-S12-029-2012) High-temperature bending strength of ZrB₂-20vol%SiC ceramics (Invited)

Guo-Jun Zhang*, Ji Zou, Shanghai Institute of Ceramics, CAS, China; Chun-Feng Hu, Toshiyuki Nishimura, Yoshio Sakka, Hidehiko Tanaka, Nano Ceramics Center, NIMS, Japan; Jef Vleugels, Omer Van der Biest, Katholieke Universiteit Leuven, Belgium

9:20 AM

(ICACC-S12-030-2012) Room Temperature Fatigue of Ultra High Temperature ZrB₂-SiC Ceramic Composites

Nina Orlovskaya*, Richard Stadelmann, University of Central Florida, United States; Thomas Graule, Jakob Kuebler, Swiss Federal Laboratories for Materials Science and Technology, Switzerland; Mykola Lugovy, Institute for Problems of Materials Science, Ukraine; C. Aneziris, M. Neubert, TU Bergakademie Freiberg, Germany

9:40 AM

Break

Novel Characterization Methods

10:00 AM-12:00 PM

Room: Coquina Salon F

Session Chair(s): Jochen Schneider, Jeremy Watts

10:00 AM

(ICACC-S12-031-2012) Identification of new stable MAX phases with tunable properties (Invited)

Johanna Rosen*, The department of Physics, Chemistry and Biology, Linköping University, Sweden

10:20 AM

(ICACC-S12-032-2012) Synthesis, microstructural characterization and transport properties of $Ti_2Al[C_xN_{1-x}]_y$ MAX phase solid solutions

Wenbo Yu, Véronique Gauthier-Brunet, Thierry Cabioc'h, Institut PPRIME, France; Loïk Gence, Luc Piraux, Université Catholique de Louvain, Belgium; Zachary Buck, Jeffrey Hettinger, Samuel Lofland, Rowan University, United States; Michel Barsoum, Drexel University, United States; Sylvain Dubois*, Institut PPRIME, France

10:40 AM

(ICACC-S12-033-2012) A first-principles investigation of the phase stability of known and hypothetical MAX phases

Martin Dahlgvist*, Björn Alling, Johanna Rosén, Thin Film Physics Division, Sweden

11:00 AM

(ICACC-S12-034-2012) The MAX Phases: The Next Horizons (Invited)

Michel Barsoum*, Drexel University, United States

11:20 AM

(ICACC-S12-035-2012) Zero-Recession Lightweight Ablators with UHTC surface layers

Takuya Aoki*, Masahito Mizuno, Toshiyuki Suzuki, Toshio Ogasawara, Yuichi Ishida, Kazuhisa Fujita, Tetsuya Yamada, Japan Aerospace Exploration Agency, Japan

11:40 AM

(ICACC-S12-036-2012) Effect of Transition Metal Additives on the Oxidation Behavior of ZrB_2

Maryam Kazemzadeh Dehdashti*, William G Fahrenholtz, Gregory E Hilmas, Missouri University of Science and Technology, United States

Design of New Compositions/Composites with Fascinating Properties

1:30 PM-3:30 PM

Room: Coquina Salon F

Session Chair(s): Michel Barsoum, Laura Silvestroni

1:30 PM

(ICACC-S12-037-2012) Mechanical Properties of ZrB_2 Ceramics: Performance Improvements (Invited)

Yutaka Kagawa*, The University of Tokyo, Japan; Shuqi Guo, National Institute for Materials Science, Japan

1:50 PM

(ICACC-S12-038-2012) Processing of ZrB_2 -SiC Matrix/SiC Fiber Composites by Means of Polymer Impregnation and Pyrolysis

Benjamin John Bowin Lai*, Jeremy Watts, Greg Hilmas, William G Fahrenholtz, Missouri University of Science & Technology, United States

2:10 PM

(ICACC-S12-039-2012) Mechanical Properties and Characterization of a Heat Treated ZrB_2 -SiC Composite

Eric W Neuman*, Gregory Hilmas, William Fahrenholtz, Missouri University of S & T, United States

2:30 PM

(ICACC-S12-040-2012) Polyureasilazane Based SiC/ ZrB_2 -SiC Fiber Reinforced Ceramic Composites

J. Nicholas*, V. Menta, K. Chandrashekhara, J. Watts, B. Lai, G. Hilmas, W. Fahrenholtz, Missouri University of Science and Technology, United States

2:50 PM

(ICACC-S12-041-2012) Synthesis of Nano-Hafnium Diboride Powder using a Modified Spark Plasma Sintering Method

Sea-Hoon Lee*, KIMS, Korea, Republic of;
Hailong Wang, Zhengzhou Univ., China; Hai-Doo Kim, KIMS, Korea, Republic of

3:10 PM

(ICACC-S12-042-2012) In situ synthesis mechanism and characterization of ultra-high temperature ceramics

Ali Goodarzi*, Amirkabir University of Tech., Iran, Islamic Republic of; Hailey Taylor, Imperial College London, United Kingdom

Fundamental Understanding and Novel Processing Methods

3:30 PM-6:10 PM

Room: Coquina Salon F

Session Chair(s): Takuya Aoki, John Lawson

3:30 PM

(ICACC-S12-043-2012) Hardness measurements above 1723 K (Invited)

Luc Jean Vandeperre*, Jianye Wang, Ezra Feilden-Irving, Finn Giuliani, Imperial College London, United Kingdom

3:50 PM

(ICACC-S12-044-2012) Investigation of Room Temperature Dislocation Mobility in metal diborides (ZrB₂) using Nano Indentation and Confinement Studies

Ghatu Subhash*, Dipankar Ghosh, University of Florida, United States

4:10 PM

(ICACC-S12-045-2012) Powder Processing Effects on the Rapid Low-Temperature Densification of ZrB₂-SiC Ultra-High

Temperature Ceramic(UHTC) Composites Using Spark Plasma Sintering

Luke S Walker*, William R Pinc, Erica L Corral, The University of Arizona, United States

4:30 PM

(ICACC-S12-046-2012) Processing and Thermal Properties of ZrB₂ with Varying Boron Isotope Ratios

Jason Michael Lonergan*, Bill Fahrenholtz, Greg Hilmas, Missouri Science & Technology, United States

4:50 PM

(ICACC-S12-047-2012) Investigations on the Mechanism of Zirconium Carbide Formation via Carbothermal Reduction of Yttria Stabilized Zirconia

Anchal Sondhi*, University of North Texas, United States; Carl Morandi, Pennsylvania State University, United States; Richard F Reidy, Thomas W Scharf, University of North Texas, United States

5:10 PM

(ICACC-S12-048-2012) Processing Thin, Homogeneous and Flexible Tapes of ZrB₂ and ZrB₂-SiC Using a Solvent-Based Tape Casting Approach

David Pham*, William R Pinc, Luke S Walker, Erica L Corral, University of Arizona, United States

5:30 PM

(ICACC-S12-049-2012) Application of the Horizontal Dip-Spin Casting (HDSC) Process to Ultra-High Temperature Ceramic Composites Fabricated with Aligned Reinforcing Phases

Manuel Acosta*, Jeffrey P Youngblood, Rodney W Trice, Purdue University, United States

5:50 PM

(ICACC-S12-050-2012) HfC and HfB₂ Powders and Coatings via Sol-Gel Processing

Saranya Venugopal*, Anish Paul, Jon Binner, Bala Vaidhyanathan, Loughborough university, United Kingdom; Peter Brown, Andrew Heaton, DSTL, United Kingdom

Friday, January 27, 2012

Methods for Improving Mechanical, Oxidation and Thermal Shock Resistance

8:00 AM-10:00 AM

Room: Coquina Salon F

Session Chair(s): Per Eklund, Sea-Hoon Lee

8:00 AM

(ICACC-S12-051-2012) Anisotropy in the electronic structure of Cr₂GeC probed by x-ray emission spectroscopy in comparison to ab initio calculations (Invited)

Martin Magnuson*, Department of Physics, Chemistry and Biology, IFM, Thin Film Physics Division, Linköping University, SE-58183 Linköping, Sweden, Sweden; Maurizio Mattesini, Instituto de Geociencias (CSIC-UCM), Facultad de CC. Física, E-28040 Madrid, Spain, Spain; Matthieu Bugnet, Vincent Mauchamp, Thierry Cabioch, Département de Physique et Mécanique des Matériaux, Institut P' UPR 3346 CNRS - Université de Poitiers - ENSMA, SP2MI, Téléport2, 86962 Futuroscope, France, France; Lars Hultman, Department of Physics, Chemistry and Biology, IFM, Thin Film Physics Division, Linköping University, SE-58183 Linköping, Sweden, Sweden

8:20 AM

(ICACC-S12-052-2012) Microstructural evolution during oxidation and its effect on strength of ultra-high temperature ceramics (UHTCs)

Eugenio Zapata-Solvas*, Doni D Jayaseelan, Imperial College London, United Kingdom;

Peter Brown, DSTL, United Kingdom; William E Lee, Imperial College London, United Kingdom

8:40 AM

(ICACC-S12-053-2012) Micromechanics Modeling of Oxidation Effects on Mechanical Behavior of ZrB₂ at High Temperature

Jun Wei*, Lokeswarappa R Dharani, Gregory E Hilmas, William G Fahrenholtz, Missouri University of Science and Technology, United States

9:00 AM

(ICACC-S12-054-2012) New Energy Applications for Ultra-Thin, Durable, Dense Zirconia Membranes

Venkat Venkateswaran, John Olenick*, Kathy Olenick, ENrG Inc., United States

9:20 AM

(ICACC-S12-055-2012) The Melt Infiltrated C/ZrC Composite by Using a Zr-Si Alloy

Linhua Zou*, Sergey Prikhodko, University of California, Los Angeles, United States; Tim Stewart, Ultramet, United States; J. M Yang, University of California, Los Angeles, United States

9:40 AM

Break

Fundamental Understanding of the Structure-Property Relationships

10:00 AM-11:40 AM

Room: Coquina Salon F

Session Chair(s): Thierry Cabioch, Luke Walker

10:00 AM

(ICACC-S12-056-2012) Rapid Single-Step

**Synthesis of Ultrahigh Temperature Ceramic
Hafnium, Tantalum, and Zirconium Diborides
by Sol-Gel Processing for Carbon-Carbon
Reverse infiltrated Ceramic Matrix
Composites**

Luke S Walker*, Victoria R Marotto, Erica L
Corral, The University of Arizona, United States

10:20 AM

**(ICACC-S12-057-2012) Phase Stability of
Al₃BC₃ under High Temperature and
Pressure: An in situ Raman Analysis**

Huimin Xiang*, Jingyang Wang, Institute of
Metal Research, China; Yanchun Zhou,
Aerospace Research Institute of Materials and
Processing Technology, China

10:40 AM

**(ICACC-S12-058-2012) Effect of Boron on the
Thermodynamic Stability of Amorphous
Polymer-Derived Si-(B-)C-N Ceramics**

Amir Hossein Tavakoli*, University of California
at Davis, United States; Jerzy A Golczewski,
Max Planck Institute for Intelligent Systems
(Former Max Planck Institute for Metals
Research), Germany; Joachim Bill, University of
Stuttgart, Germany; Alexandra Navrotsky,
University of California at Davis, United States

11:00 AM

**(ICACC-S12-059-2012) A Comparative Study of
Kinetics of Decomposition in MAX Phases at
Elevated Temperature**

It-Meng Jim Low*, Curtin University, Australia;
Weikong Pang, Tatung University, Taiwan

11:20 AM

**(ICACC-S12-060-2012) Insights into high
temperature oxidation of Al₂O₃-forming
Ti₃AlC₂**

Yanchun Zhou*, X. H Wang, F. Z Li, Aerospace
Research Institute of Materials & Processing
Technology, China; J. X Chen, Institute of Metal
Research, Chinese Academy of Sciences, China