83rd IUVSTA Workshop
"New Horizons in Boron-Containing Coatings: Modelling, Synthesis and Applications"
2 – 6 September 2018, Vadstena, Sweden
Sponsored by the Surface Engineering Division of IUVSTA

Scientific Report

The workshop took place between September 2-6 2018, in the Vadstena Klosterhotell, Vadstena, Sweden. The hotel is situated on the grounds previously held by the nons of the Bridgettine Order. The workshop attracted a large number of participants, 74, from 17 countries: Sweden, China, Germany, Austria, USA, France, Israel, Czech Republic, Bulgaria, Taiwan, Lebanon, Hungary, Japan, Slovakia, Mexico, UK, and Liechtenstein. The program included 16 invited speakers and 21 contributed talks. A very lively poster session included 13 presentations. There was plenty of discussion time after each presentation and in two separate sessions. The workshop was chaired by Johanna Rosen johanna.rosen@liu.se, Ivan Petrov petrov@illinois.edu, Joe Greene jegreene@illinois.edu, and Jens Birch jens.birch@liu.se. The event was sponsored by Linkὸping University, Knut and Alice Wallenberg Foundation, Plansee, IHI group Ion Bond, and Vetenskapradet. The attendees enjoyed the beautiful historic city of Vadstena at Lake Vättern with a most perfect Swedish summer weather. The social program included a welcome reception, a guided tour of the medieval city and cloisters, a pleasant dinner, and a theatrical night tour of the Vadstena Castle,

The workshop focused on the synthesis, properties, defect structure, first-principles design, and applications of boron-containing protective and functional thin films and coatings. The sessions involved the following topics:

- Modelling and simulation of structure/property relationships for novel B-containing materials
- Control of nanostructure/composition during PVD and CVD synthesis
- Synthesis of targets for arc and magnetron sputtering; new precursors for CVD
- Challenges for quantitative characterization of B-containing coatings
- Protective coatings: hard, wear-, corrosion-, low-friction, and high-temperature applications
- Coatings for x-ray and neutron detectors and optics

IUVSTA
1958-2018
60 years of the Union

83rd IUVSTA Workshop on
New Horizons in Boron-Containing Coatings: Modelling, Synthesis and Applications

Chairs:
Johanna Rosen
Joe Greene
Ivan Petrov
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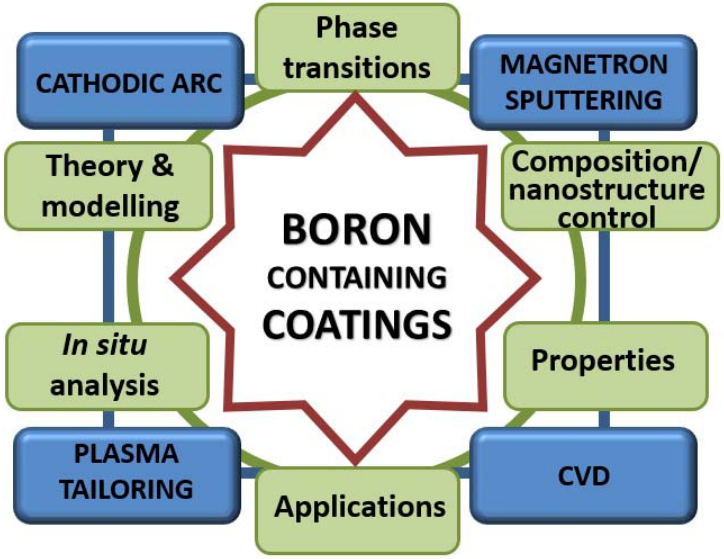
www.boronliu.com



The aim of this workshop is to initiate an in-depth discussion covering a broad range of boron-containing materials and synthesis technologies including approaches such as PVD and CVD to more complex methodologies incorporating gas- and/or power-pulsing techniques, presented in a systematic fashion, by key scientific groups worldwide.

The topics:

- Modelling and simulation of structure/property relationships for novel B-containing materials
- Control of nanostructure/composition during PVD and CVD synthesis
- Challenges for manufacturing boride sputtering targets and arc cathodes
- New precursors for CVD
- Challenges for quantitative characterization of B-containing coatings
- Protective coatings: hard, wear-, corrosion-, low-friction, and high-temperature applications
- Coatings for x-ray and neutron detectors and optics

The conclusion of the workshop is that boride/boron-containing coatings have emerged as the next generation of hard, wear-, oxidation- and corrosion-resistant coatings with many leading research groups dedicating significant effort in this area and making rapid progress. There was a general agreement to revisit this topic with a workshop in two years.

Some numbers and features

Number of participants 74
17 countries: Sweden, China, Germany, Austria, USA, France, Israel, Czech Republic, Bulgaria, Taiwan, Lebanon, Hungary, Japan, Slovakia, Mexico, UK, and Liechtenstein.
16 invited speakers
21 contributed talks.
13 poster presentations.

Sponsors : Linkὸping University, Knut and Alice Wallenberg Foundation, Plansee, IHI group Ion Bond, and Vetenskapradet

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Plenary lecture, Jan-Eric Sundgren, "Advanced Materials and Industrial Competitiveness through University-Business Cooperation".
Joe Greene presented a science history lecture on "The 14-billion Year History of the Universe Leading to Modern Materials Science"
Ivan Petrov presented an overview of IUVSTA and its activities.

83rd IUVSTA Workshop Rrogram

SUNDAY Sept 2
16:00 Registration opens
19:00 Welcome reception

	MONDAY Sept 3	TUESDAY Sept 4	WEDNESDAY Sept 5	THURSDAY Sept 6
08:20	Opening	Schneider	Jansson	Mikula
08:40	*Plenary* Sundgren			
09:00		Riedl	Chu	Houska
09:20	Zheng			
09:40		Trinidad	Persson	Magnusson
10:00	**COFFEE BREAK**			
10:30	Polcik	Jilek Junior	Widom	*Summary and Outlook*
10:50				
11:10	Mayrhofer	Greczynski	Höglund	
11:30		Sochora		
11:50	**LUNCH AND NETWORKING**			
13:30	Abelson	Wang	Ghafoor	
13:50		Vishnyakov		
14:10	Chollon	Zhirkov	Wüstefeld	
14:30	Tkadletz	Soucek	Alling	
14:50	Lee	Moraes	Campos-Silva	
15:10	**COFFEE BREAK**			
15:40	Vasina	DISCUSSION	Högberg	
16:00	Rosen		*Special Lecture* Greene	
16:20	Benke	FREE TME		
16:40	Huang			
17:00	FREE TIME		FREE TIME	
18:00	GUIDED TOUR	POSTER SESSION	18:40 APERITIF	
19:00	**DINNER**	**DINNER**	**DINNER**	
			GUIDED NIGHT TOUR AT THE CASTLE	

Financial report of the 83rd IUVSTA Workshop

Income	Unit cost (EUR)	Quantity	Sub-Total (EUR)	Remarks
Registration Fee (per person, full fee)	790	58	45,820	73 registered participants, 58 paying full fee
	500	10	5,000	10 invited speakers with reduced fee (6 paying no fee)
Sponsors	700	2	1,400	IHI group Ionbond and Plansee
VR funding	14,000	1	14,000	Conference grant from the Swedish Research Council (VR)
IUVSTA funding	6,000	1	6,000	Funding support for invited speakers
Total (EUR)			**72,220**	
Expenditures	**Unit cost (EUR)**	**Quantity**	**Sub-Total (EUR)**	**Remarks**
Meeting rooms and food (2-6 Sept)	19,700	1	19,700	Lunch, (conference-) dinner, and coffee (twice per day)
Guided tours (Monday lunch + Wenesday night))	1,990	1	1,990	
Hotel rooms (4 nights per invited speaker)	748	15	11,220	
Hotel rooms for all other attendees (4 nights per person)	748	50	37,400	8 people did not need accommodation
Miscellaneous	1,910	1	1,910	Bus/Taxi for speakers, Poster session (incl. drinks), etc.
Total (EUR)			**72,220**	

- Challenges for manufacturing boride sputtering targets and arc cathodes

At the opening, Ivan Petrov presented an overview of IUVSTA and its activities. We had a very high calibre plenary speaker, Jan-Eric Sundgren, who delivered a lecture entitled “Advanced Materials and Industrial Competitiveness through University-Business Cooperation”.

The section on modelling and simulation was very strong with invited talks by Jochen Scheider and Michael Widom and several contributed talks, including by Björn Alling, Vincent Moraes, and others. It became apparent that there is a concerted effort in the community to use ab-initio calculation in the search for novel B-containing coatings, which guide experimental work on the synthesis of novel materials. An entire family of metastable diborides has emerged with the potential for age hardening during use.

Another section of talks was devoted to CVD, lead by the invited talk of John Abelson who focused on a novel family of precursors developed for low-temperature (<300 ^{o}C) deposition routes of transition metal diboride films with superconformal coverage for diffusion-barrier, low-friction, and oxidation-resistant applications.

The majority of the presentations covered PVD synthesis of a wide-range of compositions of B-containing coatings deposited my DCMS, HiPIMS, and cathodic arc. This is an extremely active field experiencing rapid progress. One of the challenges is to find ways to control the B to metal ratio which is a challenge because unlike reactive sputtering of nitride, oxides, and carbides, there are no non-toxic reactive gases. Several techniques to control the B-content in the films were outlined, all involving using differences in the ionization cross-section of Boron and the transition metals. Powder-pack boriding to produce boride coatings on AISI 316 L steel and CoCrMo alloys for tribological and biomedical applications was covered by Ivan Campos and colleagues. While most of the PVD research targets novel protective coating, Carina Höglund described the research, development, and the industrialization of a process to deposit $^{10}B_4C$ thin films for neutron detection. Peter Polcik presented an invited talk describing the active research conducted at Plansee to overcome challenges in manufacturing high quality, pure diboride targets with almost all transition metals.

A series of talks were devoted to the specifics of quantitative characterization of B-containing coatings by TEM (Per Persson), XPS, EDX, and WDS (Vladimir Vishnyakov) and XPS, XRD, XANES, and EXAFS (Martin Magnusson).

Joe Greene presented a science history lecture on “The 14-billion Year History of the Universe Leading to Modern Materials Science”.

The overall conclusion of the workshop is that boride/boron-containing coatings have emerged as the next generation of hard, wear-, oxidation- and corrosion-resistant coatings with many leading research groups dedicating significant effort in this area and making rapid progress. There was a general agreement to revisit this topic with a workshop in two years.

The IUVSTA funds for the 83rd IUVSTA Workshop of 6000 Euros were used to cover partially the costs for workshop registration and accommodation for the invited speakers, as specified in detail in the financial report. The overall workshop budget was break-even.

Photos from the workshop can be seen here:

https://ivanp.smugmug.com/Other/83rd-ICMCTF-workshop-in-Vadstena-Sweden/

83rd IUVSTA workshop group photo

The Plenary lecture by Jan-Eric Sundgren

A very lively poster session

The theatrical night tour of the Vadstena castle

LIST OF ATTENDEES

*invited speakers are highlighted **in bold**

Jan-Eric Sundgren, EIT RawMaterials eV and the Swedish Association of Engineering Industries, Sweden
Ulf Karlsson, Linköping University, Sweden
Weitao Zheng, Jilin University, China
Peter Polcik, Plansee Composite Materials GmbH, Germany
Lars Hultman, Swedish Foundation for Strategic Research, Sweden
Paul Mayrhofer, TU Wien, Austria
John Abelson, University of Illinois, USA
Greger Håkansson, Ionbond, Sweden
Georges Chollon, University of Bordeaux, France
Sören Kahl, Husqvarna, Sweden
Anton Nikitin, Iscar, Israel
Michael Tkadletz, Montanuniversität Leoben, Austria
Mojmir Jilek, PLATIT, Czech Republic
Lars Johnson, Sandvik Coromant, Sweden
Mats Johansson-Jöesaar, Seco Tools, Sweden
Carl Björmander, Sandvik Coromant, Sweden
Jyh-Wei Lee, Ming Chi University of Technology, Taiwan
Petr Vasina, Masaryk University, Czech Republic
Linda Robinson, European Spallation Source ERIC, Sweden
Per-Olof Svensson, European Spallation Source ERIC, Sweden
Chung-Chuan Lai, European Spallation Source ERIC, Sweden
Johanna Rosen, Linköping University, Sweden
Biljana Mesic, SemeCon AG, Germany
Roman Motyka, IBC Coatings Technologies Inc., Lebanon
Peter Harper, IBC Coatings Technologies Inc., Lebanon
Fredrik Eriksson, Linköping University, Sweden
Per Eklund, Linköping University, Sweden
Justinas Palisaitis, Linköping University, Sweden
Ivan Petrov, University of Illinios, USA
Joe Greene, University of Illinios, USA
Jens Birch, Linköping University, Sweden
Feng Huang, Ningbo Institute of Materials Technology and Engineering, China
Marton Benke, University of Miskolc, Hungary
Babak Bakhit, Linköping University, Sweden
Bih-Show Lou, Chang Gung University, Taiwan

Christina Kainz, Montanuniversität Leoben, Austria
Claudia Schnitter, Linköping University, Sweden
Stanislava Debnárová, Masaryk University, Czech Republic
Sjoerd Broekhuijsen, Linköping University, Sweden
Takuya Ishihara, Azbil Corporation, Japan
Laurent Souqui, Linköping University, Sweden
Jiahao Weng, Ningbo Institute of Materials Technology and Engineering, China
Branislav Grancic, Comenius University in Bratislava, Slovakia
Tetsuhide Shimizu, Tokyo Metropolitan University, Japan,
Jimmy Thörnberg, Linköping University, Sweden
Erik Johansson, Linköping University, Sweden
Jochen Schneider, RWTH Aachen University, Germany
Helmut Riedl, TU Wien, Austria
José Martínez Trinidad, Instituto Politécnico Nacional, Mexico
Mojmir Jilek Junior, PLATIT, Czech Republic
Grzegorz Greczynski, Linköping University, Sweden
Vjaceslav Sochora, SHM, Czech Republic
Marian Mikula, Comenius University in Bratislava, Slovakia
Pavel Soucek, Masaryk University, Czech Republic
Vincent Moraes, TU Wien, Austria
Igor Zhirkov, Linköping University, Sweden
Ai-Ying Wang, Ningbo Institute of Materials Technology and Engineering, China
Hans Högberg, Linköping University, Sweden
Vladimir Vishnyakov, University of Huddersfield, UK
Ulf Jansson, Uppsala University, Sweden
Jinn P. Chu, National Taiwan University of Science and Technology, Taiwan
Per O.Å. Persson, Linköping University, Sweden
Michael Widom, Carnegie Mellon University, USA
Carina Höglund, European Spallation Source ERIC, Sweden
Naureen Ghafoor, Linköping University, Sweden
Christina Wüstefeld, Technische Universität Bergakademie Freiberg, Germany
Björn Alling, Linköping University, Sweden
Ivan E. Campos-Silva, Instituto Politécnico Nacional, Mexico,
Jiri Houska, University of West Bohemia, Czech Republic
Martin Magnusson, Linköping University, Sweden
Anders Eriksson, Oerlikon, Liechtenstein
Kan Zhang, Jilin University, China
Henrik Pedersen, Linköping University, Sweden
Xiao Zuo, Ningbo Institute of Materials Technology and Engineering, China

SCHEDULE

Names in **bold**: 40 minutes
Names in *italic*: 20 minutes

SUNDAY

Arrival, registration from 16.00. Welcome reception at 19.00.

MONDAY

Plenary speaker:
Jan-Erik Sundgren Advanced Materials and Industrial competitiveness through University-Business Cooperation

Session:
Weitao Zheng Exploring the novel B-containing superhard materials in extreme condition

Coffee break

Peter Polcik Boride sputtering targets and arc cathodes – Challenges for manufacturing technologies and target/cathode design
Paul Mayrhofer Interface and interphase controlled properties of transition metal borides: The beauty of imperfections

Lunch and networking

John Abelson CVD of Transition Metal Diborides Below 300°C: Routes to Conformal, Superconformal, Hard, Low-friction and Oxidation-resistant Coatings
Georges Chollon Structure and thermal stability of (Si)-B-C ceramics synthesized by chemical vapor deposition
Michael Tkadletz Investigation of microstructure and mechanical properties of CVD-Ti(N,B) coatings with varying B content
Jyh-Wei Lee Microstructure and mechanical property evaluation of boron-contained TiZrBN hard coatings

Coffee break

Petr Vasina Influence of chemical composition on structure and mechanical properties of W-B-C coating deposited in industrial sputtering system
Johanna Rosen TiB_2 synthesis from optimized arc and sputtering methods
Marton Benke Application of TiB_2 for soldering applications
Feng Huang Enhancing deformability of TiB_2-based hard coatings via proper metal addition

Guided tour "A historical odyssey".

Dinner

TUESDAY

Jochen Schneider Quantum mechanically guided design of borides or experimentally guided quantum mechanical calculations?
Helmut Riedl Synthesis of $W_{1-x}M_xB_2$ based ternary diborides: Challenges and Possibilities
José Martinez Trinidad In-vitro cytotoxicity of iron boride layers

Coffee break

Mojmir Jilek Junior Wear-resistant, nanostructured boron containing PVD coatings for industrial use
Grzegorz Greczynski (Preliminary title:) Plasma characterization and thin film synthesis - HfB_2
Vjaceslav Sochora Me-BN coatings simultaneously deposited by cathodic arc and magnetron sputtering

Lunch and networking

Ai-Ying Wang Superhard yet tough CrB_2 coating with superior corrosion resistance deposited by DC magnetron sputtering

Vladimir Vishnyakov Boron quantification, a comparison between different analysis techniques

Igor Zhirkov Characterization of plasma generated in magnetron sputtering from metal boride targets

Pavel Soucek Novel coatings with high hardness and fracture resistance based on metal-carbon-boron design

Vincent Moraes Ab-initio driven design of ternary diboride thin films

Coffee break

Discussion

Poster session

Dinner

WEDNESDAY

Ulf Jansson Ternary nanolaminated borides – aspects of growth and properties

Jinn Chu Boron-containing metallic-glass coating for the first-ever metallic nanotube array

Per Persson Advanced electron microscopy of borides

Coffee break

Michael Widom Mixed and partial site occupancy in boron and its carbides and nitrides

Carina Höglund $^{10}B_4C$ thin films for neutron detection

Lunch and networking

Naureen Ghafoor Impact of B_4C co-sputtering on structure and optical performance of multilayer X-ray mirrors

Christina Wüstefeld Microstructure of Ti-B-C-N nanocomposites deposited from Ti and B_4C targets

Björn Alling Theoretical investigations of mixing thermodynamics, age-hardening potential, and electronic structure of boride alloys

Ivan Campos-Silva The boriding process to improve the tribocorrosion resistance of metallic biomaterials

Coffee break

Hans Högberg Thin film synthesis and characterization of ZrB_2

Special Lecture

Joe Greene The 14-billion Year History of the Universe Leading to Modern Materials Science

Aperitif

Dinner

Guided night tour "Night patrol at Vadstena Castle"

THURSDAY

Marian Mikula Structure evolution and mechanical properties of yttrium based ternary diborides

Jiri Houska Role of boron in amorphous SiBCN and nanocomposite MSiBCN

Martin Magnusson Structure Properties of Transition Metal Borides Investigated by Xray Spectroscopy

Coffee break

Summary and Outlook