2nd WORKSHOP ON MULTIFUNCTIONAL COATINGS 2016

October 9-11th
NANTES, FRANCE

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IMN INSTITUT DES MATÉRIAUX JEAN ROUXEL

廣東工業大學
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LTN LABORATOIRE DE THERMOCINETIQUE

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Venue

Nantes is an Atlantic port city on the Loire river. Over the last 20 years, Nantes has been one of the three top French cities in terms of cultural, economic and demographic development.

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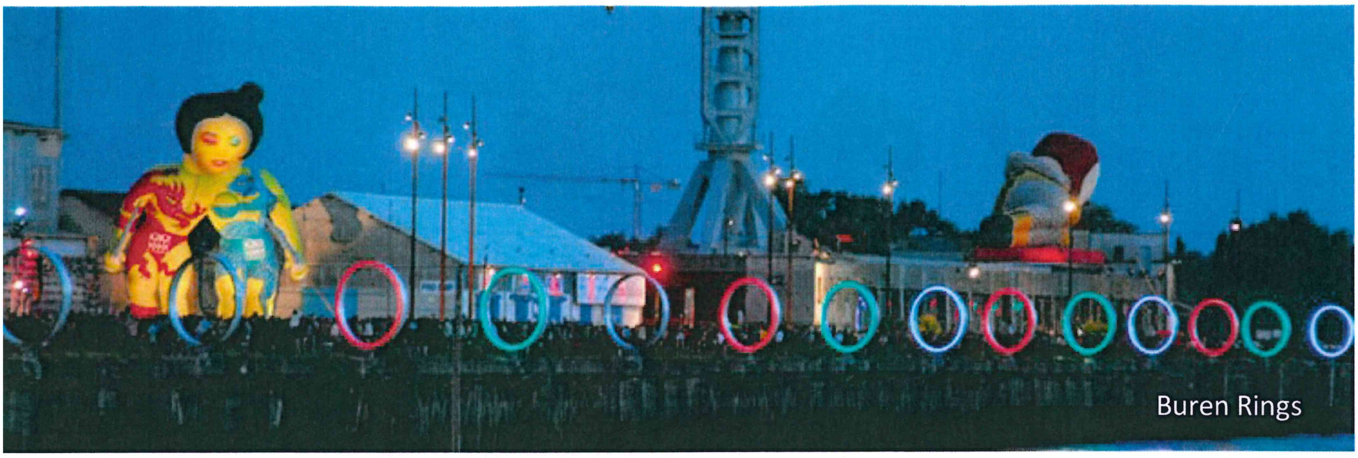
Context and Objectives

Organized by the University of Nantes (France) and Guangdong University of Technology (China), this workshop on Multifunctional Coatings (WPCCT) will be the second conference series. The 1st edition was launched by the Guangdong University of Technology in 2014 at Guangzhou (China). For the 2nd edition, we will invite renowned experts in the field of coatings for different applications to participate in the WPCCT2016 meeting at Nantes, France.

This meeting will discuss the design and preparation of the tool coatings, multi-component and multi-layer coatings, and optimization of coated tools in general for mechanical application as for example machining difficult-to-cut materials. Thermal phenomena during machining will be also considered. The workshop aims at improving communications and cooperations among the research institutions, academic organizations, tool industries and other related manufacturing companies in the field of coated tools. It will provide new opportunity for scientists, engineers, and enterprises to show their latest results, newest products, share their successful experiences and discuss the future development in the field of the coated tools.

The 2nd Workshop on Multifunctional Coatings will be held in Nantes on October 9th-11th, 2016. It will last three days. The agenda contains keynote reports, technical discussions, roundtables, achievement displays...



Buren Rings

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October 9-11th, NANTES, FRANCE

Organization

- University of Nantes / CNRS and especially by:
    - Institut des Matériaux Jean Rouxel (IMN)
    - Laboratoire de Thermocinétique (LTN)
- Guangdong University of Technology (GDUT)

Co-organization

- China Metal Cutting Tool Engineering Association
- University of Nantes
- Centre National de la Recherche Scientifique
- National Natural Science Foundation of China
- Shenzhen Vacuum Society
- Techmart Industrial Limited

Partners

- Institut de Recherche en Communications et Cybernétique de Nantes (IRCCyN)
- Polytech Nantes

2nd Workshop on Multifunctionnal Coatings- Program

MONDAY, OCTOBER 10th

8:00 - 8:45	**Registration**
8:45 - 9:00	**Welcoming Session**
	Keynotes (25'+5')
9:00 - 9:30	**Application research of PVD multilayer & composite coatings for high speed machining cutting tools** *Chengyong Wang, Guangdong University of Technology (China)*
9:30 - 10:00	**Investigation of CFRP machining with diamond abrasive cutters** *M. Ritou, A. Boudelier, S. Garnier, B. Furet, IRCCyN, Ecole Centrale de Nantes (France)*
10:00 - 10:30	**Development of Diamond-Like Carbon films for automotive application** *P. Tristant, C. Jaoul, C. Dublanche-Tixier, M. Colas, E. Laborde, F. Meunier, O. Jarry, CNRS Université de Limoges, Oerlikon Balzers Limoges (France), Oerlikon Metaplas(Germany)*
10:30 - 11:00	**High Rate HiPIMS for Cutting Tool Coatings** *T. Leyendecker , Y. Werner-Guo, J. Zhang , J.Ni , C. Schiffers, CemeCon AG Würselen (Germany), CemeCon Coating Technology Co. Jiangsu (China)*
11:00- 11:30	***Coffee break***
	Keynotes (25'+5')
11:30 - 12:00	**Amorphous alumina films: An integrated process-nanostructure-barrier properties investigation** *C. Vahlas, CIRIMAT, Université de Toulouse (France)*
	Oral Presentations (15'+5')
12:00 - 12:20	**Design and study of the Zr-B-O-N coating system fabricating by HIPIMS and Pulse DC magnetron sputtering techniques** *Tiegang Wang, University of Technology and Education, Tianjin (China)*
12:20 - 12:40	**Design and Application for Cutting Tool Coatings by a hybrid system of Ion Source-Cylindrical and Planar Arc Cathodes** *Shihong Zhang Wei Fang, Qimin Wang, Anhui University of Technology, Dokin Coating Tech. Co. Ltd (China)*
12:40- 14:00	***Lunch break***
	Keynotes (25'+5')
14:00 - 14:30	**Hard coatings for wood machining application** *C. Nouveau, LaBoMaP, ENSAM Paris, Cluny (France)*
14:30 - 15:00	**Towards an ultrahard coating nanostructuring of transition elements nitrides obtained by cathodic arc deposition.** *F. Sanchette, Université de Technologie de Troyes, LRC CEA-ICD-LASMIS Nogent (France)*
15:00 - 15:30	**Developing multi-component coatings for structural applications by hybrid PVD techniques** *Qimin Wang, Guangdong University of Technology (China)*

15:30 - 17:00	**Roundtable (90')**

-Introduction : "From hard coatings to optimized cutting tools"
A. Djouadi, IMN Université de Nantes, (France)
-Partner's activities presentation
-Discussion

17:00 - 19:00	**Poster session + *Coffee break***

20:00	**Gala Dinner "La Rosière" 35 rue de la Rosière d'Artois 44100 Nantes**

THUESDAY, OCTOBER 11th

Keynotes (25'+5')

8:30 - 9:00 **Oxidation resistance vs microstructure for the understanding of tribological performance of hard coatings**
A. Cavaleiro , F. Fernandes, M. Danek, T. Polcar, University of Coimbra, (Portugal), Czech Technical University, Prague (Czech Republic), University of Southampton(UK)

9:00 - 9:30 **Low friction and Wear resistant h-BN coatings prepared by a polymer route**
S. Yuan, S. Benayoun, B. Toury, INSA de Lyon, Université de Lyon, Ecole Centrale de Lyon, Ecully (France)

Oral Presentations (15'+5')

9:30 - 9:50 **Synthesis, structural and mechanical properties of Zr1-xMox thin films**
A. Borroto-Ramirez , S. Bruyere, N. Thurieau, E. Jimenez-Pique, J.Josep Roa, J.-F.Pierson, D.Horwat
Université de Lorraine,Nancy (France), Saarland University, Saarbrücken (Germany), Universitat Politecnica de Catalunya, Barcelona (Spain)

9:50 - 10:10 **Super-elastic thin films for biomedical applications**
A. Alhussein, S. Achache, F. Sanchette, ICD-LASMIS, Université de Technologie de Troyes, LRC CEA-ICD-LASMIS Nogent (France)

10:10 - 10:30 **Structure-property relations in zrcn coatings for tribological applications**
S. Carvalho, M. Rebelo De Figueiredo, R. Franz, R. Escobar Galindo, C. Palacio, Mitterer, Universidade do Minho, Guimarães (Portugal), University of Leoben (Austria), Centro de Micro-análisis de Materiales, Cantoblanco, Madrid (Spain), Instituto de Ciencia de Materiales de Madrid (Spain)

10:30- 11:00	***Coffee break***

Keynotes (25'+5')

11:00 - 11:30 **Use of mechanical and thermal treatments on durability and ageing of metallic substrates**
L. Lavisse, T. Montesin, V. Optasanu, M. C. Marco de Lucas, G. Pillon, P. Berger, A. Tidu, P. Peyre, M. Girault , F. Torrent, A. Kanjer, Université de Bourgogne, CEA-Saclay, Université de Lorraine Arts et Métiers Paris Tech Metz, Arts et Métiers ParisTech Paris (France),

11:30 - 12:00 **Tunable architectures and resulting properties of sculptured thin films**
N. Martin, Institut FEMTO-ST, Besançon (France)

Oral Presentations (15'+5')

12:00 - 12:20 **Heat transfer analysis between glass plate and sintered diamond wheel during the grinding process**
T. Moussa, B. Garnier, H. Peerhossaini, LTN Université de Nantes (France)

12:20 - 12:40 **Development of multi-functionalized CMC composite coating via wet chemistry**
S. Yuan, B.Terovanessian, B. Normand, INSA de Lyon, Université de Lyon (France)

12:40- 14:00 **Lunch break**

Oral Presentations (15'+5')

14:00 - 14:20 **Influence of the substrates position in an industrial PVD chamber**
A. Besnard, A. Siad, C. Nouveau, Arts et Metiers ParisTech, LaBoMaP, Cluny (France)

14:20 - 14:40 **Residual stress profile in thin films: a complex issue**
B. Girault, S. Fréour, D. Gloaguen, Université de Nantes, Institut de Recherche en Génie Civil et Mécanique, Saint-Nazaire (France)

14:40 - 15:00 **Experimental study on contact parameters at a workpiece- tool interface in HSM process**
E. Guillot, B. Bourouga, B Garnier, LTN, Université de Nantes (France)

Keynote (25'+5')

15:00 - 15:20 **Intergranular hydrogen embrittlement: Diffusion and segregation of hydrogen in nickel bi-crystals**
J. Li, J. Bouhattate, X. Feaugas et al, LaSIE, CNRS-UMR 7356, Université de la Rochelle (France)

15:20-15:40 **Nanostructured metallic coatings for the durability of structures in aggressive environments.**
J. Creus, C. Savall et al, LASIE UMR 7356, Université de la Rochelle (France)

15:40 - 15:50 **Cloture Session**

List of Posters

1	**Gum metal thin films obtained by magnetron sputteing of a Ti-Nb-Zr-Ta target** *S. Achache, S. Lamria, A. Alhussein, A. Billard, M. François, F. Sanchette, Université de Technologie de Troyes, LRC CEA-ICD-LASMIS Nogent, UTBM Belfort (France)*
2	**Elaboration and characterization of (Ti, Al, Si)N for alloy protection in severe in-service conditions** *F. Uny, E.Blanquet, F. Schuster, F. Sanchette, Université de Technologie de Troyes, LRC CEA-ICD-LASMIS Nogent, UTBM Belfort (France)*
3	**Deposition of Boron based coating for high-speed machining** *Haisheng Lin, Chengyong Wang, J. Camus, A. Djouadi, IMN Université de Nantes (France), Guangdong University of Technology (China)*
4	**Effect of different Oils on Water Cooling Conditions on Coated Tool Wear in machinig of difficult-to-machine material**

	Haisheng Lin, Chengyong Wang, A. Djouadi, IMN Université de Nantes(France), Guangdong University of Technology (China)
5	**Microstructure and property of diamond-like carbon films with Al and Cr co-doping using a high power impulse magnetron sputtering** *Wei Dai, Qimin Wang, Guangdong University of Technology (China)*
6	**Influence of Ti1-xAlxN (x=0.48, 0.58 and 0.66) insertion layers on microstructure, mechanical and thermal properties of TiAlN/CrAlN nano-multilayer coatings** *Ziqiang Liu, Li Chen,Yuxiang Xu, Central South University, Changsha (China)*
7	**Influence of Ta-addition and layer arrangement on the structure , mechanical and thermal of TiAlN coatings** *Yan Yang, Li Chen, Yu X. Xu, Central South University, Changsha (China)*
8	**Improving performance of groove-textured tools in dry milling of Ti-6Al-4V Alloys** *Ze Wu, Southeast University, Nanjing (China)*
9	**White Layer Formation in High Speed Machining of Hardened steel** *Duan Chun-Zheng, Zhang Fang-Yuan, Xu Xin-Xin, Wang Min-Jie, University of Technology, Dalian (China)*
10	**Experimental study on cutting performance of coated tools with different surface quality** *Rongjuan Wang, Chengyong Wang, Guangdong University of Technology (China)*
11	**Relationship of microstructure, mechanical properties and hardened steel cutting performance of TiSiN-based nanocomposite coated tool** *Yaohui Yuan, Donghai Yu, Chengyong Wang, Haisheng Lin, Qimin Wang, Guangdong University of Technology (China)*
12	**Basic Theory and Cutting Tool Technology for High Speed and High Efficiency Machining of Typical Difficult-to-Cut Materials** *Li Pengnan, Liu Deshun, Niu Qiulin, Tang Siwen, Qiu Xinyi， Ma Jiying, Hunan University of Science and Technology, Xiangtan (China)*
13	**Microstructure and Corrosion Resistance of the AlTiN Coating Deposited by Arc Ion Plating** *Qi-Xiang Fan, Tie-Gang Wang, Yan-Mei Liu, Zheng-Huan Wu, University of Technology and Education, Tianjin (China)*
14	**Microstructure and properties of the TC4 alloy layer strengthened by powder-mixed near-dry electrical discharge surface modification** *Min Li, Lanrong Cai, Hui Yang, Jingling Wang, University of Technology and Education, Tianjin (China)*
15	**Effects of boronizing process on the friction coefficient and surface roughness of AiSi02 and h11** *Mounia Belaid, Farouk Boukari, Abdou Djouadi, Annaba University(Algeria), IMN Université de Nantes (France)*
16	**Properties of pulsed-DC sputtered Cr-B-N films as a function of their boron content** *D. Pilloud, J.F. Pierson, Institut Jean Lamour Université de Lorraine, Nancy (France)*
17	**Textured growth of AlN films deposited on Si(100), Si(111) and Pt(111) substrates by DC reactive magnetron sputtering** *B. Riah, A. Ayad, N. Rouag, L. Chekour and M. A. Djouadi, Université des frères Mentouri Constantine (Algeria), Université Constantine (Algeria), IMN Université de Nantes (France)*
18	**Research on multilayer Printed Circuit board High speed microdrilling process and tools** *Lijuang Zheng, Guangdong University of Technology (China)*

Abstracts

Keynotes and Oral Presentations

Application research of PVD multilayer & composite coatings for high-speed machining cutting tools

Chengyong Wang[a], Lijuan Zheng[a], Yaohui Yuan[a], Haisheng Lin[a], Qimin Wang[a]
[a] *School of Electromechanical Engineering, Guangdong University of Technology, Guangzhou Higher education Mega Center Panyu District, Guangdong, P.R. China*

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Focusing on the characteristics of high-speed machining chilled gray iron and vermicular graphite cast iron for auto parts and hardened steel for precision molds, this presentation will develop novel multi-layered and multi-component coatings based on Ti-Si-N nanocomposite coatings, which combine hybrid intragranular and grain boundary nanostructure, gradient nanostructure, and adaptive surface active structure. The multi-scale relationships among the coating microstructure, the macro properties of the coatings, and the machining and tribological performances of the coated tools will be presented. The design and fabrication theory and related techniques of the proposed new multi-layered and multi-component nanocomposite coatings with strengthened multi-functions will be investigated. A new hybrid high-power impulse plasma-assisted magnetron sputtering and will be created to produce the coatings. The related coating process parameters will be optimized. The mechanism and methods of the micro-abrasive polishing on the surface of the cutting tools will be also explored. High-performance coated tools which can be utilized successfully on high-speed machining cast irons and hardened steels, and the related designing theory and manufacturing techniques are fabricated. The relations between the structure of the multi-layered/multi-component nanocomposite coatings and the machining performance of the coated cutting tools will be revealed, which will establish the technical base for applying the high-speed hard-milling coated tools.

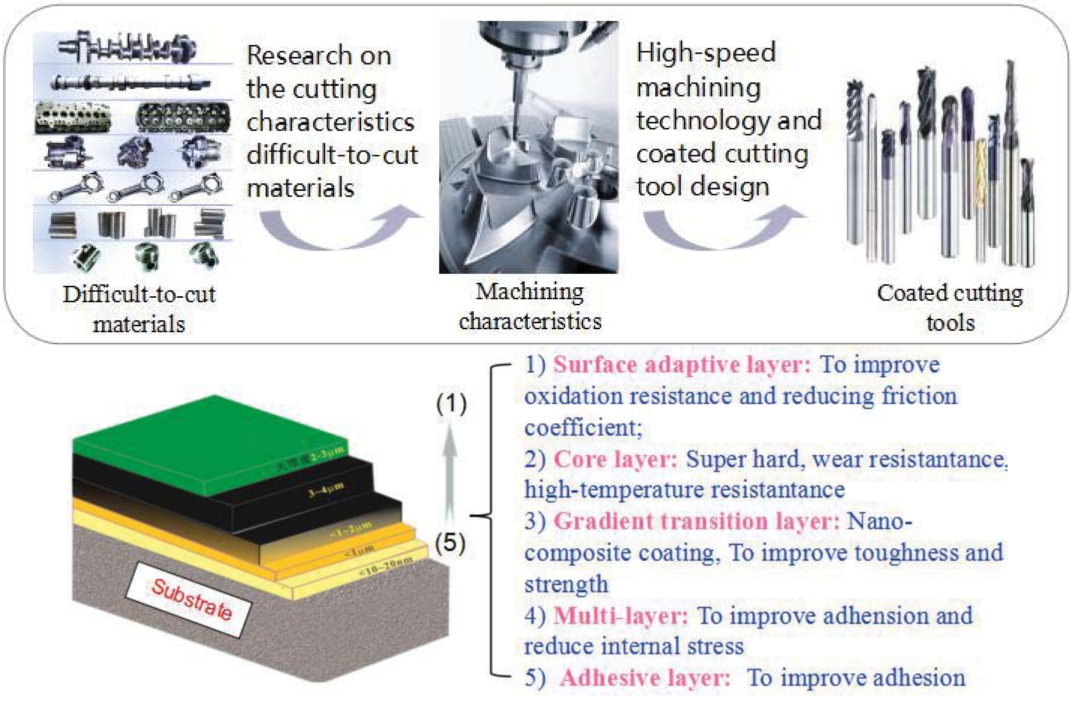

Fig.1 Design of multi-hybrid nanocomposite coatings-functionally gradient coatings based on the cutting characteristics of difficult-to-cut materials

Investigation of CFRP machining with diamond abrasive cutters

M. Ritou, A. Boudelier, S. Garnier, B. Furet

IRCCyN - Institut de Recherche en Communications et en Cybernétique de Nantes 1, rue de la Noë BP92101 44321 Nantes Cedex 03 - France

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Abstract:

The machining of CFRP material is a new industrial challenge. Due to fibre abrasivity, classical cutting tool technologies present a limited lifespan. Diamond abrasive cutter is an original solution. The impact on machinability and surface integrity of this new tool technology is investigated and leads to interesting results.

Development of Diamond-Like Carbon films for automotive application

P. Tristant[a], C. Jaoul[a], C. Dublanche-Tixier[a], M. Colas[a], E. Laborde[a], F. Meunier[b], O. Jarry[c]

[a] Université de Limoges, CNRS, Sciences des Procédés Céramiques et de Traitements de Surface, UMR 7315, CEC, 12 rue Atlantis, 87068 Limoges, France
[b] Oerlikon Balzers, 5 Allée Skylab, BP6810, 87068 Limoges, France
[c] Oerlikon Metaplas, Am Böttcherberg 30-38, 51427 Bergisch Gladbach, Germany

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Hydrogenated amorphous carbon (a-C:H) thin films are among the best coating solutions for the reduction of automotive fuel consumption because of their very good tribological properties. Friction losses are indeed one of the main sources of energetic consumption in an automotive engine. 80 % of friction occurring in the valve train system is only due to the cam-follower contact, representing 20 % of the total losses in the engine. That is why the reduction of friction coefficient in dry and lubricated conditions is still in demand. Quite high values for hardness are also required to withstand the severity of this contact. Nowadays, DLC coatings are a standard and well recognized solution but research development is still necessary to improve the performance’s baseline of standard DLC regarding friction performance without impact on wear resistance.

Each deposition process lead to a DLC film with specific properties correlated with hydrogen content and sp^3/sp^2 bonded carbon ratio. Many metallic or non-metallic elements have been introduced in the DLC (Diamond-Like Carbon) matrix to improve some properties. For example, a first study is dedicated to DLC containing fluorine (non-metallic element). Objective is to control F content in order to obtain hard a-C:H:F with enhanced tribological properties compared to standard a-C:H without changing deposition parameters. DLC films are produced by radio-frequency PECVD in an industrial coater with different combinations of precursors in order to explore various F/H ratios. As a second study, metallic elements which are not able to form carbide phases, like Al, could dope the DLC layer without altering the matrix properties. a-C:H:Al films are produced by a hybrid PECVD - magnetron sputtering process using different powers on the Al target to explore various Al/C ratios. In a dynamic configuration, multilayer coatings with variable Al content can be designed.

For all the studies, X-ray photoelectron spectroscopy is performed to determine the chemical composition of the films and the structure is observed by Raman spectroscopy. Hardness is measured by nanoindentation and tribological tests are performed with an alternative ball-on-disc tribometer to measure wear resistance and friction coefficient in dry conditions.

High Rate HiPIMS for Cutting Tool Coatings

Toni Leyendecker [a], Yuan Werner-Guo [a], Jimmy Zhang [b] Joe Ni [b], Christoph Schiffers [a]
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[b] *CemeCon Coating Technology Co., Ltd., No. 81 Suhong West Road, Industrial Park, Suzhou, Jiangsu, P.R. China*

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A deposition rate as high as possible is a key requirement to every commercial coating process. This paper will introduce a new HiPIMS concept for increasing the deposition rate. The concept is based on the CemeCon door-assembly design, which avoids any cable between pulse unit and cathode, and features a full synchronization between the HiPIMS sources and a dedicated table Bias. Plasma characterization demonstrates that this results in highest ionization. Together with reduced re-sputtering this novel process regime gives a so far unachieved deposition rate for HiPIMS. Case studies show how this new hardware and process design turns the advantage of the HiPIMS technology such as enhanced film adhesion, denser morphology and better coating uniformity all around 3D objects into user benefits for cutting tool applications.

A lot of research is currently dedicated to the machining process of titanium and heat resistant super alloys based on nickel, iron or cobalt. Jet engines and gas turbines made of this material group operate at a higher working temperature and thereby raise the energy conversion efficiency. Key obstacles to productive metal processing are the extreme cutting temperature, the high strength and the tendency to stick to the carbide substrate of the tool. TiB_2 films are a promising candidate due the high hardness of this ceramic material and its low affinity to non-ferrous metals. This next step in the development of HiPIMS broadens the application range of TiB_2 from the traditional aluminium manufacturing sector to super alloys.

Case studies show how a dedicated HiPIMS process leads to fine-grain TiB_2 morphology. The film shows hardness levels above 4.000HV – which is typical for TiB_2 films – combined with low young's modulus. High toughness makes it rather suitable for operations like thin wall milling for jet engines. Milling tests in the aircraft sector demonstrate how the superb adhesion of HiPIMS supports the machining of titanium and super alloys further.

Si doping of TiAlN is a known method for enhancing the hardness of the film. A second case study shows show HiPIMS further promotes this concept. The HiPIMS parameters such as pulse power, pulse length, on/off time offer a toolbox for exactly tailoring the morphology of the film. Nanoindentation data show that the fine grain HiPIMS film gives an unsurpassed H^3/E^2 value. Such a favorable ratio of hardness to toughness is very beneficial for interrupted cutting i.e. milling and paves the way for using the HiPIMS technology for a wide range of component coatings.

Amorphous alumina films:
An integrated process-nanostructure-barrier properties investigation

Constantin Vahlas

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Abstract: A series of chemical vapor deposition (CVD) processes are presented for the deposition of amorphous alumina (a-Al_2O_3) films with tuneable characteristics. Aluminum tri-isopropoxide (ATI) or dimethyl aluminum isopropoxide (DMAI) are introduced in the reactor either by vaporization or by direct liquid injection (DLI). All processes provide compact films with typical surface roughness values lower than 2 nm, except the DLI-ATI one which yields films with columnar structure. Very high-field (20 T) solid state 27Al NMR spectroscopy reveals that films processed from vaporized ATI and from DLI-DMAI in temperature ranges 360-600 °C and 150-450 °C, respectively, contain more than 40 at. % of 5-fold coordinated aluminum sites, while the percentage of $^{[6]}$Al remains less than 10 at. %. Hydrothermal ageing of DLI-ATI films processed on glass substrates simulated by a standard sterilization cycle results in the increase of the root mean squared roughness of the surface of the coatings from ca. 17 to 61 nm and in the increase of the porosity, without affecting the adhesion of the coatings. Films processed from vaporized ATI on 304L stainless steel provide increasing corrosion protection from a 0.1 M NaCl solution at room temperature with increasing thickness up to 500–600 nm, as revealed by polarization curves and electrochemical impedance spectroscopy. SAED-TEM,

Design and study of the Zr-B-O-N coating system fabricating by HIPIMS and Pulse DC magnetron sputtering techniques

Tie-Gang Wang*, Qi-Xiang Fan, Yanmei Liu

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Abstract

Zirconium diboride, ZrB_2, as one of the hard refractory compounds, has many interesting intrinsic characteristics, i.e., high melting point more than 3300 K, high hardness, excellent oxidation resistance，corrosion resistance as well as wear resistance. Its film has already been deposited via CVD, PECVD and PVD techniques. However, they were still restricted to apply on the cutting tool surface due to their high brittleness. The addition of nitrogen atoms was expected to improve the film toughness through forming nanocomposite microstructure, namely the nanocrystallines ZrN or ZrB_2 were surrounded by amorphous BN phase. But the existence of a large amount of BN phase severely reduced the coating hardness. In view of this, two targets ZrB_2 and Zr were used to deposit the Zr-B-N coatings for supplementing sufficient Zr atoms in coating so that the coating hardness can be increased.

It turned out that the BN phase started to volatilize when the temperature is over 300 ℃, which to a certain extent restrict the use of Zr-B-N coatings at high temperature. In order to improve heat resistant ability of Zr-B-N coatings, an appropriate quantity of O atoms was also added into the coating by HIPIMS (high power impulse magnetron sputtering) and pulse DC (direct current) combined magnetron sputtering technologies. It is expected that the solid solution of O atoms or the formation of new phase ZrO_2 can prohibit the oxidation of the coating and the diffusion of O element into coating at high temperature. On the other hand, the existence of polycrystalline ZrO_2 and formation of borate during friction will play a very good role on lubrication, which would also improve the coating wear resistance. In this work, above a series of coatings including ZrB_2, Zr-B-N, and Zr-B-O-N were prepared by HIPIMS and Pulse DC combined magnetron sputtering technologies. Correspondingly, the composition, microstructure, mechanical properties, and tribological behaviors of these coatings were studied comparatively, some valuable conclusions were drawn.

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Keywords: Zr-B-O-N coating; HIPIMS; Microstructure; Mechanical properties; Tribological behavior

Design and Application for Cutting Tool Coatings by a hybrid system of Ion Source-Cylindrical and Planar Arc Cathodes

Shihong Zhang[1, 2, *], Wei Fang[1, 2], Qimin Wang[1, 2]

（[1] Research Center of Modern Surface and Interface Engineering, Anhui University of Technology，[2] Dokin Coating Tech. Co. Ltd., China）

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Design multilayer and nanocomposite coatings with excellent performance by develping hybrid PVD systems of ion source, cylindrical arc, high power pulse and planar arc has become a new hotspot of high-speed dry cutting tool coatings research. In this study, the developed ion source technology could achieve the high energy density and enough pre-plating cleaning, which effectively improved the adhesion strength between coatings and tool substrates; The hybrid of cylindrical arc and planar arc equipments which based on the principle of arc discharge present high concentration plasma source in the deposition process. The coatings deposited by cylindrical arc cathodes has denser microstructure, less particles and defects, and the coatings deposited by planar arc cathodes has advantage of good adhesion strength and high coating-forming efficiency. Deposited by the above-mentioned PVD system which inherits the merits of ion source, cylindrical arc and multi arc ion plating, the AlCrN, AlCrSiN and AlTiSiN multilayer and nanocomposite coatings have dense microstructure, excellently comprehensive mechanical properties and lower friction coefficient, which have a great success in the high-speed & dry cutting fields.

HARD COATINGS FOR WOOD MACHINING APPLICATION

Corinne Nouveau[a]

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Over the next 10 years, wood manufacturing will need to develop and adapt to the demands from the construction industry. This will require the adaptation and the improvement of the current tools used in the primary and secondary processing of wood. One solution for this improvement in wood cutting tools is surface treatment.

Although surface treatments have been used in metal-cutting tools since the end of the 1960's, the market of surface treatments, such as coatings deposited via PVD (Physical Vapor Deposition) or CVD (Chemical Vapor Deposition) have not been well developed in the cutting tools of wood.

Unfortunately, we cannot simply apply metal-cutting tool coatings to woodcutting tools. Indeed, contrary to a piece of tantalum or titanium, wood is a not homogeneous material and contains defects (knots among others), some glue and silica (composite materials), and some water and tannins (which can promote tribocorrosion). Thus, wood is a material that cannot be compared with metals or alloys manufactured with surface-modified tools.

This work deals with the optimization of PVD CrN hard coatings (technical deposition process), their optimization thanks to characterizations (by XPS, SIMS, XRD…) and some laboratory and industrial results of their application on wood cutting tools (routing and lathing).

According to physico chemical, mechanical and structural characterizations, but also after laboratory and industrial wood cutting tests, PVD CrN hard coatings are very good candidates to improve the service life of wood cutting tools in normal and extreme cutting conditions.

Finally, the objective of this work was to show the followed methodology to develop a coating for a specific application. The final objective was to show the relation between research (optimization of hard coatings) and the real life (cutting tools that will better meet the expectations of the toolmakers and thus the end-users). Actually, we do not realize hard coatings only for fun!

Towards an ultrahard coating... nanostructuring of transition elements nitrides obtained by cathodic arc deposition.

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Materials to be machined have now very good mechanical behaviours and cutting speeds become high. Thus, tools have to work in more severe conditions and they must be more and more perfomant. The quality of machined surfaces is also a parameter to optimize, particularly in the aeronautical field. This presentation first deals with the development of coatings on ultrahard tungsten carbide tools for machining nickel based super alloys used in aircraft construction; Inconel 718. Nickel based super alloys are difficult to machine since they keep a very high mechanical strength at high temperature. For this application, multilayer nitrides based coatings were obtained by cathodic arc deposition.
One limitation of lubricant-free machining is the impact of high temperature on the structure and properties of cutting materials. Moreover, the development of ultra high speed machining tends to increase this critical temperature. These considerations highlight the need for a stable material operating at elevated temperature. Adding silicon in a transition metal nitride can lead to increase significantly the thermal stability of the coating's material. The second part of the presentation is dedicated to the properties of nitrides containing silicon with a nanocomposite microstructure, also obtained by cathodic arc deposition.

Developing multi-component coatings for structural applications by hybrid PVD techniques

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Abstract: To increase the lifetime and performance of cutting/forming tools and machine parts/components, there are increasing demands for coatings. Coatings for structural applications require combinations of properties such as a relatively high hardness, good adhesion, wear and oxidation resistance. To fulfill these requirements, new coating materials and new synthesizing methods are needed to be developed.

Due to the excellent mechanical and physical properties, coatings with nanocomposite microstructure are attracting much attention for application on structural applications. Various multi-component nano-structured coatings were fabricated for obtaining not only superhardness, but also improved oxidation resistance, thermal stability, wear resistance, etc. Among them, some of the coatings were tailored to obtain excellent cutting performance on the high-speed cutting tools.

In this presentation, some multi-layer and multi-component coatings, such as MeAlSiN (Me= Ti, Cr), AlCrSiON, Ti_2AlN coatings were developed for structural applications by a hybrid PVD coating system. The related coating microstructure and properties will be presented.

Keywords: multi-component coatings; hybrid PVD technique; coating microstructure; coating properties.

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OXIDATION RESISTANCE VS MICROSTRUCTURE FOR THE UNDERSTANDING OF TRIBOLOGICAL PERFORMANCE OF HARD COATINGS

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The extremely aggressive conditions of loading and temperature existing in several mechanical applications, such as e.g. in cutting tools, require an effective protection of the base materials. Therefore, it does not find surprising the extensive application of hard coatings for overcoming the problems occurring in the components in service. Taking into account the loading service conditions, it seems logical that the development carried out in last decades in this field had been focused on a further and further improvement of either the mechanical strength, preferentially at high temperatures, or the thermal stability in protective and oxidative / corrosive environments. Globally, transition metal nitrides (TM-N) possess very high hardness, good fracture toughness and suitable oxidation / corrosion resistance at high temperature, reason why they were, for long time, the preferred solution in the field of hard coatings. Among the extensive list of TM tested and studied in last decades for hard coatings systems, Ti and Cr have been the most successfully used as base chemical elements in the TM-N systems. The optimization of their performance at high temperatures has been achieved by modifying their chemical composition with alloying elements, being Si and Al those showing the best final results. However, although significant improvements in the high temperature behavior has been already achieved, many times the in service performance is far from what could be expected.

In this talk, we will discuss the importance of the microstructure / structural arrangement of the coatings, in parallel with their high temperature oxidation resistance, to shed some light on the tribological behavior and in-service cutting performance of transition metal nitrides hard coatings deposited by PVD techniques. We will focus our attention on Ti and/or Cr-based systems alloyed with Al and/or Si. Progressively we will present: (i) the basic properties (hardness, adhesion, fracture toughness) and their relationship with the (micro)structure of the coatings, with special focus on phase / layers arrangement; (ii). the high temperature oxidation resistance as a function of the alloying elements; (iii) the tribological performance, friction coefficient and wear rates, as a function of the temperature, and (iv) the in-service performance during machining tests. The final discussion will be focused on the interaction between tribological behavior, high temperature stability, mechanical properties and in-service performance.

Low friction and Wear resistant *h*-BN coatings prepared by a polymer route

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Hexagonal boron nitride (h-BN) can be used as environmentally friendly and protective coatings in order to increase lifetime of wear pieces mechanically stressed in aeronautic field. Actually, h-BN presents all the expected properties for such application, meaning high thermal and chemical stabilities and especially a solid lubricant behaviour even at high temperatures. Alternatively to usual methods (CVD, sputtering, PLD), BN coatings can also be achieved by the polymer derived ceramics (PDCs) route.

This presentation deals with the preparation of h-BN coatings from a polymeric precursor onto titanium-based substrate. The ceramization process is led via an innovative optical treatment by IR irradiation to overcome the problem of the metal stability at high temperature (needed in classical process). Chemical analyses show that the obtained crackless coatings annealed under argon atmosphere have a micro composite structure composed by a TiN interphase covered by a $BN_{1.08}(B_2O_3)_{0.08}$ μ-layer. The infrared ceramization treatment used being sufficient, no significant composition weathering is observed within time. Improved structural characterizations show a good crystallisation rate of the ceramic with a grains size within 3nm. Hereafter, tribologic and mechanic properties have been investigated using scratch test, calotest and tribometer. Results exhibit a good solid lubricant behaviour of the coating linked to its weak friction coefficient, actually, measurement realized in a micro pin on disk configuration (normal charge: 10N) gives a value of about 0.1. Finally, the good adhesion between the substrate and the coating is explained by the formation of Ti-N-B bond at the interphase.

Synthesis, structural and mechanical properties of $Zr_{1-x}Mo_x$ thin films

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Nanostructured thin films offer outstanding mechanical features relative to single phase microcrystalline materials. Extremely fine grained structures allow taking the best profit of the Hall-Petch hardening. Such arrangements were successfully exploited and extensively studied in order to design relatively tough hard and super-hard ceramic–ceramic nanocomposites. Metal–metal systems are in essence softer but less brittle than their ceramic–ceramic counterpart. They are particularly interesting due to a high hardness *H* achieved through Hall-Petch hardening while keeping an elastic modulus *E* characteristic of metals. This is a powerful strategy to significantly improve the *H/E* ratio, a parameter known to drive the friction behavior of materials.

In this work $Zr_{1-x}Mo_x$ thin films were synthesized on glass substrates by co-sputtering molybdenum and zirconium targets in the presence of argon with *x* in the 0.31-0.94 range. From X-ray diffraction analysis and TEM images was possible to observe an evolution of the samples structure from a nano-crystalline solid solution of Zr in the bcc lattice of Mo to clusters of Zr(Mo) nano-crystalline in an amorphous matrix. The coherence length deduced from X-ray diffractograms was around 1 nm to 9 nm depending on the composition. Mechanical measurements shows that the films exhibited high hardness *H*, low Young's modulus *E* and therefore high *H/E* ratio compared with the bulk of Zr and Mo. We also found a low friction coefficient values for all the samples. Finally an inverse Hall-Petch effect was observed for coherence length lower than 7 nm.

SUPER-ELASTIC THIN FILMS FOR BIOMEDICAL APPLICATIONS

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Super-elastic Titanium based thin films Ti-23Nb-0.7Ta-2Zr-(O) (TNTZ-O) (at.%) were deposited by direct current magnetron sputtering (DCMS) in Ar + O_2 atmosphere. The effects of oxygen doping (TNTZ-O) on the microstructure, mechanical properties and biocompatibility of the as-deposited coatings were investigated.

Nano-indentation measurements show that 1 sccm of reactive gas in the mixture is necessary to reach acceptable values of hardness and Young's modulus. Mechanical properties are considered in relation to the films compactness, the compressive stress and the changes in the grain size [1-2].

Data on Bacterial inactivation and biocompatibility are reported in this study. The biocompatibility tests showed that O-containing samples led to higher cells proliferation. The sputtered films showed bactericidal activity as followed by surface potential and pH changes within the disinfection process [2].

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STRUCTURE-PROPERTY RELATIONS IN ZrCN COATINGS FOR TRIBOLOGICAL APPLICATIONS

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Energy consumption in mechanical devices and other environmental problems related to their application in industrial operations are nowadays important driving forces for many studies aiming for improvement of the energy efficiency. The deposition of a hard coating on the surface has been proven to be an effective technology. For example, enhanced mechanical properties help to increase the lifetime of cutting tools or automotive components and thus also enable their application with a reduced amount of lubricants, hence lowering the environmental impact and the relative manufacturing costs.

Within the present work, ZrCN coatings were synthesised by dc reactive magnetron sputtering. The study addresses the influence of the nitrogen and/or carbon concentration in the coating on the structure, as well as on the mechanical properties, tribological behaviour and consequently on the cutting performance on dry conditions.

Information about the chemical composition was obtained by glow discharge optical emission spectroscopy and Rutherford backscattering spectroscopy. The evolution of the crystal structure, studied by X-ray diffraction, revealed the formation of a mixture of fcc phases of ZrN, ZrCN and ZrC, (NaCl-type). The optimum hardness value of ~29 GPa was found for the coating with Zr/(C+N) = 1.3. The highest hardness can be associated to the formation of a ZrCN solid solution.

Additionally, the presence of an amorphous CN_x phase in coatings deposited with high N_2 and/or C_2H_2 flows could be evidenced by Raman spectroscopy and X-ray photoelectron spectroscopy. This amorphous phase can act as a lubricant resulting in a low coefficient of friction as shown in the conducted ball-on-disc tests at room temperature. In fact tribological tests with the hardest coating revealed a high friction, but moderate wear. A drop of the COF to 0.1-0.2 could be observed for the coatings with Zr/(C+N) $\leq$ 0.7, which is related to the formation of the additional amorphous CN_x phase. However, these coatings show a lower hardness (17-18 GPa), but moderate wear in the ball-on-disc tests.

Within the frame of this work ZrCN coatings were sputtered also on tungsten carbide tools. The performance of these inserts was compared to a commercial tool. After turning tests, it possible to prove that the ZrCN coatings offer significant potential for operate in extreme environments for high speed turning.

Use of mechanical and thermal treatments on durability and ageing of metallic substrates

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Titanium and its alloys are widely used in aeronautical, marine and chemical industries for their good mechanical properties, high resistance to corrosion and low density. However, the tribological properties of titanium must be improved for many mechanical engineering applications and also its high temperature corrosion resistance especially for aeronautical applications.In last years, laser surface processing has been used in industry and in research laboratory for improving tribological properties of Ti alloys (corrosion, wear and/or fatigue resistance). Indeed large compressive stresses as well surface hardening induced by mechanical process as shock laser seem to play a positive role in the oxidation resistance of materials. This behaviour is observed on pure Ti and Zr.

One hand, first purpose was to study the effect of process setup, as laser and surrounding atmosphere on the light element insertion when the targets are treated with a nanosecond pulse duration Nd:YAG laser. This process modifies the surface by formation of specific layers under the substrate. These layers show different properties which are largely influenced by the presence and the repartition of insertion elements in the layers. Then, we specially compare the fretting behavior of commercially pure titanium plates functionalized with titanium oxynitride films obtained by two methods: reactive physical vapour deposition (PVD) and surface laser treatments by using a nanosecond Nd:YAG laser emitting at 1.064 µm.

To understand and distinguish the laser light element with oxidation during fretting test, laser treatments were done in a reactive atmosphere composed of different mixtures of oxygen and nitrogen. Moreover, ^{18}O isotope was used for laser treatments with the aim of distinguish the insertion of oxygen due to the laser treatment with respect to oxidation processes associated to Tribological Transformations of Surface (TTS) during the fretting test in air.

In the other hand, an experimental campaign led on commercial pure Ti is carried out to understand the impact of laser shock as a protection against oxidation at high temperature. Laser-peened specimens are compared to untreated samples in terms of oxidation behaviour at high temperature (700°C) in dry air during long times (3000h) and short times (100h). Specimens were evaluated for their oxidation resistance by TGA.

For these two study, same kind of observations, analyses and characterisations were subsequently performed, by several techniques SEM/EDS, NRA, XRD and Raman spectroscopy. We show that these two laser treatment, reactive hardening by light insertion or laser speening respectively promotes better tribological behaviour for and also substantially reduces the mass gain and prove the presence of Nitrogen enrichment located at the interface between oxide and α-case layers.

Tunable architectures and resulting properties of sculptured thin films

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Structuring of thin films is gaining scientific interest since the last decades and the development of new methods of synthesis became a technological requirement. As a result, it is now quite difficult to quantify the right number of processes focused on the fabrication of nanostructured materials. In the well-known race for multifunctional materials, an enhancement of the material behaviors due to the modification of its surfaces or by means of thin films deposition appears as an attractive way.

This presentation aims at illustrating how functionality of metallic and ceramic thin films sputter deposited can be tuned with a structural approach: the GLancing Angle Deposition (GLAD) [1]. This technique employs oblique angle deposition and controlled substrate motion to form a structure composed of nanometer scaled columns of designed shape. It allows the fabrication of films with a carefully engineered structure at the sub-micron scale. Thus, very original architectures (zigzags, spirals, oriented columns and so on) of the films can be produced, which provide new geometries of the film structure [2-4].

The basic principle of this attractive technique using a fixed and/or mobile substrate as well as the resulting properties will be presented in terms of structural characteristics and surface morphologies. Mechanical performances as well as some physical behaviors of such thin films will be presented especially showing the correlations between dimensions, shapes and geometries of produced architectures and the resulting properties. Finally, a non-exhaustive assessment of potential applications of these structured thin films will be reviewed.

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HEAT TRANSFER ANALYSIS BETWEEN GLASS PLATE AND SINTERED DIAMOND WHEEL DURING THE GRINDING PROCESS

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Heat transfer analysis is of great importance for temperature prediction during grinding. Indeed, grinding parameters have to be adjusted to accelerate the manufacturing process while minimizing thermal damage of the workpiece [1]. The temperature survey is especially critical for the glass material grinding due to its low thermal conductivity inducing a high temperature rise. In our study, temperatures at different locations in the sintered diamond composite of the grinding wheel are measured using thermocouples and a radio transmission technique. The glass temperature is measured using thermocouple strips on both sides of the glass plate, the grinding wheel providing the electrical connection between them. Results during grinding with a 6500 rpm rotation velocity show a temperature lower than 80°C inside the grinding wheel while a temperature up to 900°C is found on the glass. An inverse approach is used to compute the wall heat flux and the temperature at the wall of the grinding wheel using a 2D axisymmetric heat transfer model. A 1D nonlinear heat transfer model including conduction and radiation is used to obtain the wall heat flux of the glass material. Knowing temperatures and heat fluxes on both sides of the interface, one can deduce information on thermal contact resistance, generated heat flux and partition ratio. So, the heat generated by the grinding is estimated between 223 and 399 W depending on the grinding process conditions and is localized on the glass side of the interface. The thermal contact resistance at the glass/sintered diamond composite figures out to be very high with a value greater than 3.8 10^{-3} $m^2K.W^{-1}$ [2].

Keywords: Grinding, glass, sintered diamond, heat transfer, thermal contact resistance, moving heat source

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Development of multi-functionalized CMC composite coating via wet chemistry

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Corrosion degradation of materials and structures remains one of the most important issues that leads to depreciation of investment goods in many key industry sector (automotive, aircraft, energy production, building and electro-devices). The deposition of barrier layer is a wildly used efficacious approach to reduce corrosion risk by preventing contact of susceptible materials to corrosive environment. However, the development of modern industry requires more powerful barrier coating providing, meanwhile, multi-functionalities such as: wear resistance, electrical/thermic conductivity, self-healing, biocompatibility as well as special superficial texture for specific applications. Moreover, nanostructuring process is a powerful method allowing to enhance anticorrosion performance and/or impart novel functionality to conventional compounds. Recent work of colleagues in laboratory MATEIS of INSA of Lyon, have proved the feasibility of various innovative multifunctional composite coatings via different methods for instance sol-gel, electrospinning, cold spray… Meanwhile-, relevant characterizations have been developed, such as environmental electrochemical analyses, impedance, tribo-corrosion, stress corrosion cracking…

INFLUENCE OF THE SUBSTRATES POSITION IN AN INDUSTRIAL PVD CHAMBER

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The development in laboratory of a functional coating with properties given by a particular composition and structure represents a long and hard scientific work, recognized by several publications and communications. But the real award is the successful transfer at and industrial scale. The volume of the chamber, the size of the sources or the number of samples are some examples of major changes in the deposition process between laboratory and industrial equipment. Long comparative studies could help but simulation tools are adequate to answer the problem with reasonable time and precision.
In this study, two substrates orientations (0° and 85°) are placed at different positions compared to the center of a rectangular target (16'' x 5'' – 406 mm x 12.7 mm): +150 mm, +75 mm, 0 mm, -75 mm, -150 mm. In order to reduce the number of parameters, a unique pure chromium deposition produced the ten coatings. The evolution of the film thickness and the column tilt angle presents a clear dependence on the position and orientation of the substrate in the chamber relatively to the target. Thus, under a constant deposition process optimized in laboratory the properties of the samples will change. The complete simulation study using SRIM [1], SIMTRA [2] and Simul3D [3], is performed and compared to the experimental results. The numerical films present a high correlation with the experimental ones. Consequently, studying the numerical results concerning ejection, transport and growth will give clues to understand the experimental process.
An apparent local target is defined for each sample with particular position and surface compared to the "physical" target. A discussion about the definition of the angles (substrates orientation angle versus incidence flux angle) explains the variation reported for the column tilt angles. The thickness variation is found depending on a combination of substrate position and orientation relatively to the center of the target and of the target emission probability. Particles energy and angles distributions sharpen the differences between all samples. Information about roughness and film density evolution are given.
In conclusion, the simulation is a powerful and essential tool to understand and predict with a good accuracy the influence of the substrates position in a particular chamber, i.e. process transfer from lab scale to industrial scale.

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Residual stress profile in thin films: a complex issue

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Several X-Ray Diffraction (XRD) experimental methods exist in order to determine in-depth strain profiles, necessary data to depth stress profiles evaluation in polycrystalline materials. Among those, one can mention the radiation change, grazing incidence, and the scattering vector methods. Similarly, analysis of depth-dependent strain data is performed through different procedures targeting depth-resolved stress determination. One can cite inverse Laplace transforms, the polynomial method and the analysis of the curvature of the $\sin^2\psi$ plots. An historical review of the experimental techniques and calculation methods has been published in [1]. Nevertheless, referring to the round robin test led by Behnken *et al.* [2] reporting upon stress profiles determination performed by different scientific sources (universities, research institutes and industry) upon a unique specimen, access to true stress in-depth profile remains critical. Indeed, Fig. 1 clearly shows a high results dispersion happening not only upon stress profile evolution upon sample thickness but even on the type of mechanical stress state (compressive or tensile). Authors note that even if appreciable statistical scatters are present and systematic errors cannot be excluded, the various calculation methods yield stress profiles that may differ qualitatively and quantitatively [2].

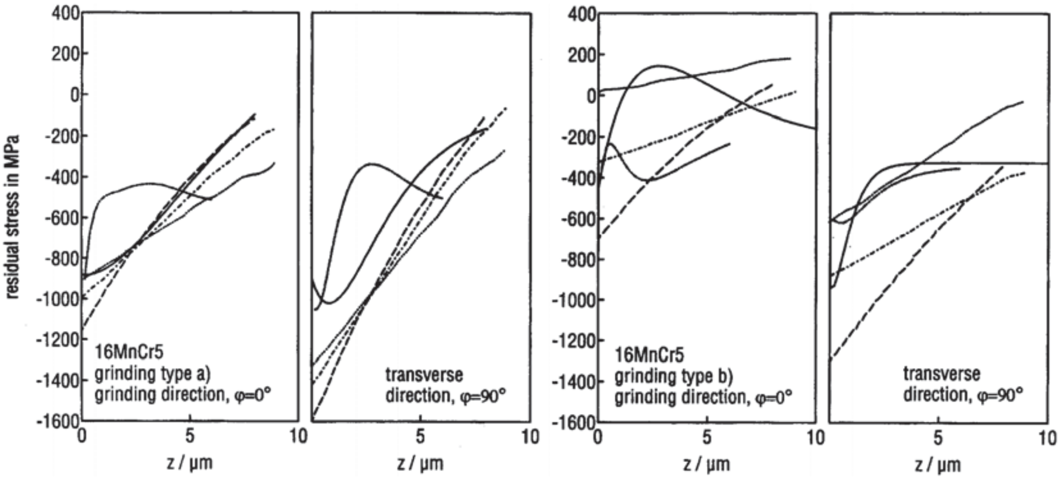

Fig. 1: *Stress profiles beneath the surface of the ground steels, evaluated by several participants from their experimentally determined D($\sin^2\psi$) dependencies.*

Unreliability of the currently stress gradient analysis is shown without actually ability to decide between those (regarding unknown stress profile). Whatever the method used, a macroscopic (first-order) elastic residual strain gradient is assumed when this assumption is no longer valid for plastically deformed polycrystalline materials. Indeed, following mechanical loadings such as those used in metal-forming processes, resulting plastic anisotropy induces large intergranular (second-order) strains, due to the plastic deformation accommodation between grains [3]. The latter are superimposed, and XRD measurements give a combination of first- and second-order strains. Thus, large differences in strain levels are observed between grains families having different lattice orientation within the polycristal. The problem becomes even more complicated in the case of in-depth internal strain (first- and second-order) inhomogeneity i.e. strain gradient. In addition, most of material, such as multifunctional coatings, do present microstructural gradients (e.g. grain size, chemical composition,…) and thus properties heterogeneities that directly affect stress profile analysis.

The remaining fundamental question is thus how to obtain the true macroscopic strain profile from the measured strains (obtained thanks to specific {hkl} X-ray reflections) in a material when a superposition of all microstructural effect and mechanical consideration occur.

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Experimental Study on Contact Parameters at a Work Piece – Tool Interface in a HSM Process

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Abstract

The study relates to the characterization of thermal sliding contact work piece-tool under large strains, representative of the secondary shear zone of a High Speed Machining Process (HSMP). The literature shows that authors consider a perfect thermal contact condition and suppose that the heat flux generated by friction is affected on both sides of the sliding interface in the ratio of the thermal effusivities of materials in contact. However the distribution of the normal stress at this interface is large and the thermal contact must become imperfect before the release of the chip. The improvement of the simulation of high speed machining process (HSMP) requires the checking of these two assumptions. The proposed experimental approach is founded on temperature field measurement by thermocouples in order to estimate thermal sliding contact parameters at the part/tool interface seat of large strains in same conditions as the HSMP: the thermal contact resistances R_{TC}, the generated heat flux φ_g and share ratio α of φ_g. Experiments were carried out on friction device that reproduces mechanical and thermal contact conditions of a HSMP at the tip tool. The experimental plan allows to study the influence of sliding speed and materials in contact on the thermal parameters. Results show that heat flux is divided into thermal effusivities ratio of materials in contact; but the thermal contact remains systematically imperfect.

Keywords: sliding thermal contact resistance, sharing coefficient of generated heat flux, parameters estimation, temperature measurement.

Intergranular hydrogen embrittlement: Diffusion and segregation of hydrogen in nickel bi-crystals

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Abstract

Hydrogen Embrittlement (HE) is one of the causes mainly evoked in premature rupture of industrial components exposed to aggressive environment. Many studies have been conducted in order to understand the mechanisms involved during this degradation. However the effects of the grain boundaries (GBs), triple junction (TJs) and several defects (dislocations, vacancies …) in FCC materials and their interactions with hydrogen on the mechanisms of metal damages remain a controversy. Actually, several works suggest that in FCC materials the grain boundaries represent preferential paths for hydrogen diffusion (short-circuit diffusion), and this kind of hydrogen diffusion along GBs is higher than the interstitial diffusion. However, GBs contain different defects, particularly, dislocations and vacancies. These defects are able to trap hydrogen affecting the diffusion mechanisms. Although a number of theories have been proposed to describe the role of GBs for hydrogen diffusion and segregation, none of them is able to give an exact answer. In addition, there is little suitable experimental data available.

Therefore, in present study, we have studied at the first time some nickel single crystals. We evaluate the hydrogen diffusion and trapping mechanisms using the electrochemical permeation (EP) coupled to the thermal desorption spectroscopy (TDS). Later, we propose to screen several bi-crystals of pure nickel with different grain boundaries (**Σ11-**50°*30<110>{311}*, **Σ11-***129°30<110>{332}*, **Σ3-***70°30<110>{111}* and **Σ5-***37°<100>{310})*. For each bi-crystal, therefor for each grain boundary, the diffusion and segregation of hydrogen is studied by EP and TDS. In addition, Molecular Dynamics (MD) simulations have become a useful method to comprehend the becoming of hydrogen in these types of GBs. The results allow us to associate the short-circuit diffusion and trapping phenomena to the grain boundaries character (excess volume, defects density and distribution …)

Nanostructured metallic coatings for the durability of structures in aggressive environments

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Abstract

Nanostructured materials are widely developed for specific applications in industry combining enhanced mechanical and tribological properties and corrosion resistance.

It was reported that the decrease of the grain size leads to important modifications of mechanical properties of materials [1-2].

Many studies focused on the influence of grain size refinement on the evolution of theses properties. The impact of grain size on the hardness evolution of electrodeposited coatings was thoroughly studied [3]. The impact on corrosion resistance has been less studied , perhaps because multi-scale observations were necessary to identify the degradation mechanism.

The enhancement of the mechanical properties can also be achieved by varying the configuration of the coatings, so nano-multilayer coatings or nano-composite metal matrix coatings become an interesting domain for the improvement of the corrosion resistance with enhanced mechanical properties.

In this document, we will present two research activities that are devoted to metallic coatings as eventual candidate for the substitution of electrodeposited hard chromium or to improve the binding resistance of coatings for fasteners application [4-5].

Keywords: nanostructured coatings, electrodeposition

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Abstracts

Posters

GUM METAL THIN FILMS OBTAINED BY MAGNETRON SPUTTEING OF A Ti-Nb-Zr-Ta TARGET

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Abstract

TNTZ quaternary superelastic coatings with a beta structure were successfully deposited by magnetron sputtering of a Ti-Nb-Zr-Ta target. In this work, we discuss the effects of argon pressure and negative substrate bias voltage on the microstructure, morphology, texture, mechanical properties and superelastic behavior of these coatings. The results show that the texture is random at high deposition pressure and it becomes {110} at the lowest deposition pressure (i.e. 0.2 Pa). Applying negative bias voltage causes the disappearance of {110} texture and promotes the appearance of {100} and {111} textures. The texture evolution is related to the ion bombardment of the growing film and to the surface mobility of adatoms. The highest hardness and Young's modulus are obtained for the Oxygen Free Gum Metal (OFGM) film deposited at the lowest deposition pressure (i.e. 0.2 Pa) and a bias of -200 V. The Evolution of the mechanical properties is discussed as a function of the film density, the compressive stress and grains' size changes. It was found that the film deposited at 0.2 Pa and floating potential presents the greatest depth recovery ratio. It is due to the fact that the film is dense and its texture is {110}. The negative bias voltage seems to have an unfavorable effect on the superelasticity.

Elaboration and characteoperationsrization of (Ti, Al, Si)N for alloy protection in severe in-service conditions

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The ceramic hard coatings, especially TiAlN thin films received a good interest for several decades in protection of cutting tools owing to their high hardness and oxidation resistance [1]. However, the increasing machining speed in cutting operations led to the development of quaternary nitrides as TiAlSiN, allowing to ever increase the mechanical and chemical properties of TiAlN and thus improve the wear resistance of coatings [2].

In this work, high Al-containing AlTiN coatings will be deposited in an industrial CVD scale unit (Bernex BXPro series, IHI Ionbond AG) by means of ammonia and aluminum and titanium chlorides. Aluminum chlorides will be generated by in-situ chlorination [3]. The possibility to reduce deposition temperature and to incorporate Si in the coatings is also explored.

Coatings are characterized in terms of composition and microstructure. Microstructural changes, mechanical properties and oxidation resistance will be studied as regards to the Al-content in the coatings and annealing temperature.

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Deposition of BN based coating for high-speed machining

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Boron nitride, especially in its cubic phase (c-BN), is a significantly interesting material for cutting applications thanks to its super-hardness (up to 60 GPa), thermal and mechanical properties. Reports on the formation of c-BN by means of PVD, PACVD or even CVD methods indicate ion bombardment of growing film as an essential condition [1]. Nevertheless, this high level of ion bombardment has some drawbacks, namely high level of stress and low adhesion, which inhibit the deposition of thick films.

This study deals with attempts to overcome these drawbacks by using:
-Bi-step process with nucleation and growth steps.
-Adding a third element such as zirconium and hafnium into the c-BN based film.

It is well know that the nucleation conditions [2, 3] need more ion bombardment and energy than growth one. So our goal is to optimise the nucleation conditions in order to synthesis c-BN films by RF magnetron sputtering technique. After, as a second step, by reducing the ion bombardment during growth process, we are success to reduce the stress (down to 2 GPa) but with maintaining the c-BN content as high as possible (> 80%).

Nano-composite ZrBN has the phases of ZrN, h-BN and c-BN. ZrBN deposited by optimized condition has dense structure, improved adhesion and corrosion resistance. Low alloy steel tools with ZrBN coating and nitriding treatment gave 6.5 times higher tool life in comparison with uncoated tools during the cutting of wood. The structure and properties of HfBN coating are also under research. Our goal is to achieve HfBN coated tool with high cutting performance in high-speed machining.

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Effect of different Oils on Water Cooling Conditions on Coated Tool Wear in Machinig of Difficult-to-Machine Materials

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Wet cutting is the most common cooling method used during the cutting of difficult-to-machine materials, such as titanium alloys, compacted graphite cast iron (CGI). However, this method is associated with high costs, pollution and hazards to operators. Minimal quantity lubrication (MQL) is an effective environmentally friendly cooling method, but is not suitable for difficult-to-machine materials because of its low heat transfer capacity. This paper proposes the use of oils on water (OoW) as a cooling method for the machining of Ti-6Al-4V alloy and CGI using coated tools.

Cutting force, cutting temperature, surface roughness and tool wear of coated tools under EOoW with three different spraying locations (rake face, flank face, rake and flank faces) and IOoW with different amounts of water, in the machining of Ti6Al4V and CGI, were studied. We found that $EOoW_{rf}$ (spray to rake and flank faces) and IOoW (1.2 L/h water) gave the least adhesion and lowest tool wear among EOoW and IOoW, respectively, because of the best combination of cooling and lubrication effect. Cooling condition (EOoW and IOoW), coated tool (CVD Al_2O_3-based and PVD TiAlN-based) and machined materials (CGI and Ti6Al4V) should be matched in order to get the best cutting performance.

Because of better protected cutting tool, better strengthened oil film and the changes of thermal properties of machined material, better cutting performance can be achieved by using as low as possible cooling temperature. Therefore, a newly developed CAOoW condition, in which OoW was delivered by cryogenic air, was proposed. We found that CAOoW gave higher cutting performance in both Ti6Al4V and CGI than EOoW and IOoW.

Microstructure and property of diamond-like carbon films with Al and Cr co-doping deposited using a hybrid beams system

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Abstract: DLC films with weak carbide former Al and carbide former Cr co-doping (Al:Cr-DLC) were deposited by a hybrid beams system comprising an anode-layer linear ion beam source (LIS) and high power impulse magnetron sputtering using a gas mixture of C_2H_2 and Ar as the precursor. The doped Al and Cr contents were controlled via adjusting the C_2H_2 fraction in the gas mixture. The composition, microstructure, compressive stress, mechanical properties and tribological behaviors of the Al:Cr-DLC films were researched carefully using X-ray photoelectron spectroscopy, transmission electron microscopy, Raman spectroscopy, stress-tester, nanoindentation and ball-on-plate tribometer as function of the C_2H_2 fraction. The results show that the Al and Cr contents in the films increased continuously as the C_2H_2 fraction decreased. The doped Cr atoms preferred to bond with the carbon while the Al atoms mainly existed in metallic state. Structure modulation with alternate multilayer consisted of Al-poor DLC layer and Al-rich DLC layer was found in the films. Those periodic Al-rich DLC layers can effectively release the residual stress of the films. On the other hand, the formation of the carbide component due to Cr incorporation can help to increase the film hardness. Accordingly, the residual stress of the DLC films can be reduced without sacrificing the film hardness though co-doping Al and Cr atoms. Furthermore, it was found that the periodic Al-rich layer can greatly improve the elastic resilience of the DLC films and thus decrease the film friction coefficient and wear rate significantly. However, the existence of the carbide component would cause abrasive wear and thus deteriorate the wear performance of the films.

Keywords: Diamond-like carbon; Al:Cr co-doping; Residual stress; Elastic recovery; Tribology

Influence of $Ti_{1-x}Al_xN$ (x=0.48, 0.58 and 0.66) insertion layers on microstructure, mechanical and thermal properties of TiAlN/CrAlN nano-multilayer coatings

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Abstract: Nano-multilayered TiAlN/CrAlN coatings combining advantages of TiAlN and CrAlN are considered to be a promising candidate for advanced machining process. Here, the structure and thermal properties of TiAlN/CrAlN_1, _2 and _3 multilayer coatings combining with $Ti_{1-x}Al_xN$ (x=0.48, 0.58 and 0.66) and $Cr_{0.32}Al_{0.68}N$ sublayers were investigated. The TiAlN/CrAlN_1 and TiAlN/CrAlN_2 coatings with single phase cubic structure reveal the epitaxial growth between $Ti_{1-x}Al_xN$ (x=0.48 and 0.58) and CrAlN, which lead to increased hardness with value of ~33.9 and ~31.7GPa due to interfacial strengthening, respectively. However, the epitaxial loss of TiAlN/CrAlN_3 with further increase x up to 0.66 of $Ti_{1-x}Al_xN$ sublayer exhibits mixed cubic-wurtzite structure and thereby an interior hardness of ~28.1 GPa. The insertion of TiAlN layer with epitaxial interfaces suppresses the N-loss process and enhances thermal stability during annealing. The onset of deleterious wurtzite-AlN formation in TiAlN/CrAlN_1 during thermal annealing increases to 1000^{o}C due to the epitaxial interface structure. After oxidation at 900^{o}C for 10h, the TiAlN/CrAlN_1, _2 and _3 multilayer coatings exhibit oxide scales of ~1.4, 0.8 and 1.0 μm, respectively. Increasing oxidation temperature to 1000^{o}C results in a complete oxidation of TiAlN/CrAlN_1 and TiAlN/CrAlN_2, whereas the TiAlN/CrAlN_3 is partly oxidized with an oxide scale of ~2.7 μm.

Keywords: TiAlN/CrAlN;Interfacial structure; Thermal stability; Oxidation resistance

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Influence of Ta-addition and layer arrangement on the structure, mechanical and thermal of TiAlN coatings

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Abstract: In order to study the effect of Ta on the structure, mechanical and thermal properties of TiAlN coating, $Ti_{0.42}Al_{0.58}N$, $Ti_{0.37}Al_{0.58}Ta_{0.05}N$ and $Ti_{0.33}Al_{0.58}Ta_{0.09}N$ monolithic as well as TiAlTaN/TiAlN multilayer coatings are prepared by cathodic arc evaporation. Alloying with Ta into TiAlN induces a structural transformation from single phase cubic of $Ti_{0.42}Al_{0.58}N$ to multiphase of Ta-containing coatings consisting of mixed cubic-wurtzite as well as hexagonal Ta_2N, and thereby a drop in hardness from ~35.2 to ~32.2GPa. However, The addition of Ta improves the thermal stability of $Ti_{40}Al_{60}N$ coating. $Ti_{35}Al_{60}Ta_5N$ and $Ti_{30}Al_{60}Ta_{10}N$ coatings can maintain their hardness up to 1000 ^{o}C while the hardness of $Ti_{40}Al_{60}N$ decreases from 35.2GPa to 29.4GPa after annealing at 1000 ^{o}C. The Ta-containing sublayers are stabilized in the cubic structure by the TiAlN sublayers due to coherency strains, and thus results in an overall cubic structure. The $Ti_{0.37}Al_{0.58}Ta_{0.05}N$/TiAlN and $Ti_{0.33}Al_{0.58}Ta_{0.09}N$/TiAlN multilayer coatings with hardness of ~32.8 and ~34.3 GPa behave stronger age-hardening, corresponding to the annealed hardness values of ~37.3 and ~37.6 GPa at 900 ^{o}C, respectively. Additionally, incorporation of Ta has a positive effect on the oxidation resistance of TiAlN.

Keywords: TiAlTaN; TiAlN/TiAlTaN; hardness; thermal stability; oxidation resistance

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Improving performance of groove-textured tools in dry milling of Ti-6Al-4V alloys

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Abstract

The groove-textured tools were fabricated by making textures on the rake faces and filling them with molybdenum disulfide. Dry milling of Ti-6Al-4V alloys was carried out with the groove-textured tools and conventional tools for comparison. Results show that the groove-textured tools can reduce the resultant cutting forces, the cutting temperatures and the power consumptions by 10-20%, 5-10% and 5% or so, respectively. Meanwhile, the developed tools can improve the tool lives by 20% or so. The radial width of cut, the cutting speed as well as the axial depth of cut all have statistical and physical effect on the power consumption per unit volume in dry milling of Ti-6Al-4V alloys, while the feed per tooth seems to have no significant effect on that. The mechanism for improved performance of the groove-textured tools can be mainly interpreted as their self-lubricating function.

Keywords: Surface texturing, Dry milling, Ti-6Al-4V alloys, Taguchi method

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White Layer Formation in High Speed Machining of Hardened steel

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With the progress of machining technology and the advent of new cutting tool materials, high machining precision and low surface roughness can be obtained by dry and hard high speed machining hardened steel using new PCBN insert, ceramic insert or cemented carbide inserts. A lot of researches show that metamorphic layer exits on the machined surface, metamorphic layer is composed of white layer and dark layer that have great influence on use life of workpiece.

GCr15 bearing steel and 40CrNiMoA alloy steel were employed in experiments. The specimens were observed by optical microscope and scanning electron microscope (SEM) to study the microstructure of the metamorphic layer and the influence rules of cutting speed, flank wear and carbon content on white layer thickness. The phase composition of the machined surface was analyzed by X ray diffraction technique(XRD), the formation mechanism of white and dark layers were explored as well.

The average hardness of workpieces is 60HRC, the orthogonal cutting experiments were carried out on the machining center. The cutting tool is PCBN insert with a rake angle of -10° and a relief angle of 7°, the negative chamfer was grinded to improve the tool life and the parameter is $b_{\gamma 1}\times\gamma_{01}$=0.05mm×-20°. Cutting speed was changed from 200m/min to 550m/min, flank wear VB pre-prepared was changed from 0mm to 0.2mm.

The microstructure of machined surface changes greatly, the grain refinement can be observed in the white layer which is at the top of the machined surface. The white layer is composed of martensite, residual austenite, carbide and the phase transformation occurred during the white layer formation process. Large amount of cutting heat was produced during machining, resulting in the austenitic transformation. As the result of high quenching speed, the white layer microstructure is fine cryptocrystalline martensite. The carbon in the workpiece is not completely dissolved during rapid cooling, leading to supersaturated carbon precipitating in the form of carbide. The microstructure of dark layer is more coarse than white layer, but the size of carbide particles in the dark layer is smaller. The temperature field is gradient distribution along the depth direction and the dark layer is in the tempering zone, so the microstructure of dark layer is tempered martensite. The boundaries between the white layer and the dark layer are obvious, but the dark layer and the substrate is difficult to distinguish.

The white layer thickness increases with cutting speed when the cutting speed is low, while the white layer thickness decreases when the cutting speed continues to increase. More heat is generated with the increase of cutting speed, which leads to higher white layer thickness. However, at range of high cutting speed, most of heat produced by machining is taken away with chips quickly, so the white layer thickness has the tendency of decrease.

The white layer thickness increases as the flank wear increases. One reason is that the flank wear causes more intense friction and extrusion between the flank face and the machined surface, resulting in more heat, so the white layer thickness increases. Another reason is that the austenite phase transition temperature decreases with the increase of stress and strain and the white layer thickness increases.

The white layer thickness of high carbon content material is higher than of low carbon content material. The high carbon content material is more easy to austenitize, which increases chance of martensite formation. Morever, when the mass fraction of carbon is lower than 1%, the critical cooling rate of martensite decreases with the increase of carbon content and the hardenability of steel increases. For white layer that is based on the mechanism of phase transformation, high hardenability implies higher white layer thickness. GCr15 which has higher carbon content is easier to obtain martensite.

The residual austenite content of machined surface is larger than that of the substrate. The residual austenite content increases first and then decreases with the increase of cutting speed. The temperature of machined surface increases with the cutting speed, and the austenization is more adequate. However, most of heat is taken away by chip during high speed machining, austenitic transformation cannot be fully carried out, so the residual austenite content of machined surface decreases.

Experimental study on cutting performance of coated tools with different surface quality

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Abstract：PVD coating is formed through the deposition of micro particles which are formed through evaporation and gasification of the target material on the surface of the substrate under vacuum conditions.The size of the micro particles ranges from 0.5um to 3um and the micro particles obviously increase the surface roughness of the coating and the friction between the tool and the workpiece during the cutting process, which has an important influence on the service life of the coated tool. The post treatment of coated cutting tool by micro abrasive slurry jet (MASJ) is an effective method to improve the surface quality of the coating. In this paper , two kinds of coated tools with different surface quality were obtained by one time and two polishing processes of MASJ. The two kinds of polished coated tools and the untreated coated tool are used for hardened steel turning test. The wear curve shows that the service life of one time polished coated tool is the longest. The cutting forces of the three kinds of tool increase with the increasing of cutting speed, feed rate and cutting depth, and the surface roughness of the machined workpieces decrease with the increasing of cutting speed and cutting depth and increase proportionally with the increasing of feed rate. Under the same conditions, the one-time polished coated tool performs the best, and the second is the coated tool which is not polished, and the twice polished coated tool performs the worst. This shows that if the thickness of the coating is removed too much the cutting performance of the coated tool can be changed. In conclusion, the proper MASJ processing technology can effectively improve the processing performance of coated tools.

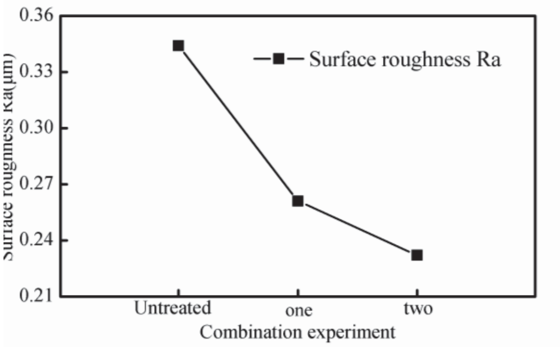

Fig.1 The result of MASJ combined machining

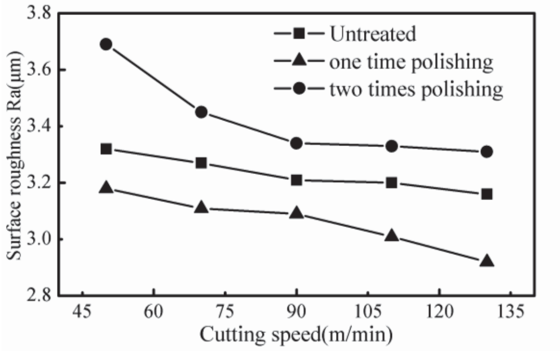

Fig.2 The influence of cutting speed on surface roughness

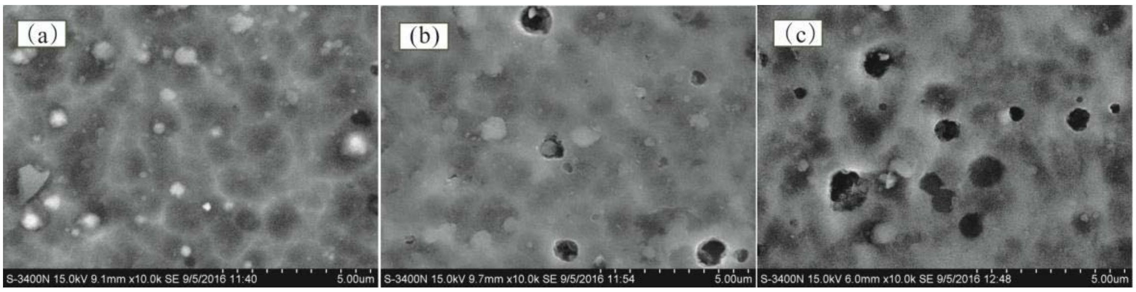

Fig.2 The surface topography (a)Untreated (b)one time polishing (c) two times polishing

Relationship of microstructure, mechanical properties and hardened steel cutting performance of TiSiN-based nanocomposite coated tools

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TiSiN coating has many excellent properties such as dense microstructure, extremely high hardness and better oxidation resistance, While its high stress and weak adhesive strength largely limited its application on high speed machining. To further improve the performance of these coatings, quaternary or even higher ordered nanocomposite coatings have been developed by adding alloying elements such as Al, Cr, V, Y, Zr, Mo, Hf etc. In additions, the excellent performance of these coated tools largely depends upon the chemical and compositions of coating materials, and the microstructure of coating also plays a major role in determining the cutting performance of the coated tools.

In this paper, four kinds of TiSiN-based nanocomposite coatings, TiSiN, TiCrSiN, TiAlSiN and TiCrAlSiN, were deposited on cemented caibide tools by a PVD equipment which combines HCD (hollow cathode discharge) with MS (magnetron sputtering) techniques. Microstructure, Micro-hardness (denoted as H), Young's modulus (denoted as E), Friction-wear and oxidation properties of these coatings were examined. The cutting force, flank wear rate and its wear morphology of as-deposited coated mills (Diameter 4 mm) under the condition of high speed dry milling hardened steel DIN 1.2311 (52 HRC) were measured. The effect of Al or/and Cr alloying elements additions on the properties of TiSiN-base coatings were analyzed, and the relationship of microstructure, mechanical and oxidation properties and hardened steel cutting performance of these coatings also were explored.

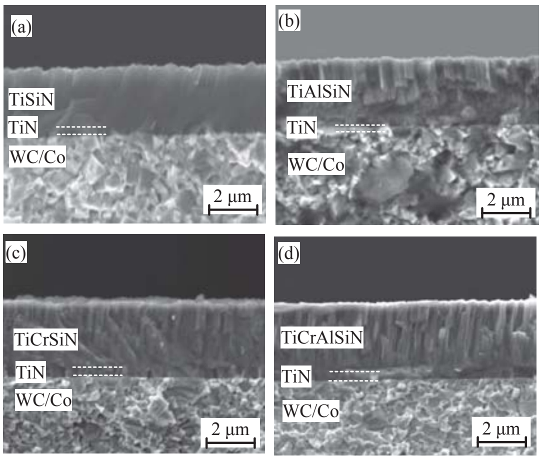

Fig. 1 Cross-sectional SEM morphologies of the as-deposited coatings

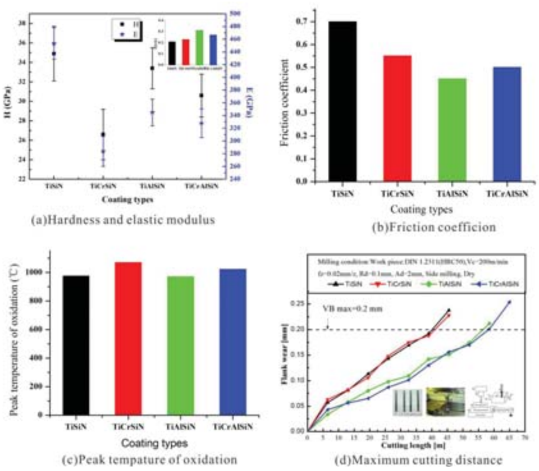

Fig. 2 Properties and performance comparisons of as-deposited coatings

Results show that TiSiN coating exhibited denser structure than others. As the Al or/and Cr were doped in, obvious columnar structures were observed (as shown in Fig.1). With Al or/and Cr additions, TiSiN-based coatings exhibited higher H^3/E^2, lower friction coefficient, and better oxidation resistance than TiSiN coating (as shown in Fig.2). The cutting force and flank wear rate of TiAlSiN and TiCrAlSiN coated tools increased more gently than other coated tools, which mean that the TiAlSiN and TiCrAlSiN coatings behaved better dry milling performance than TiSiN and TiCrSiN coatings.

Basic Theory and Cutting Tool Technology for High Speed and High Efficiency Machining of Typical Difficult-to-Cut Materials

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Study on high-speed and efficient machining technology and theory of difficult-to-cut materials, such as high strength steel, titanium alloy, high temperature alloy, CFRP, reveals serrated chip formation mechanism and the influence and damage of brittle plastic deformation of the cutting edge, and the friction and wear mechanism of the tool of high speed cutting under the action of multiple space-time mechanical-thermal coupling field, set up high speed cutting tribology control model and tool life prediction model.

Research the low defect, high efficiency drilling technology for high strength CFRP, analyses the relationship between the quality of hole drilling and drilling force, processing parameters, explores drilling mechanism and characterization methods of drilling defects, and the relationship between the cutting force and drilling defects, set up the prediction method drilling force and the drilling defect.

Study on the matching and cutting parameter optimization method of tool material and workpieces material, MQL technology, cutting performance stability prediction and cutting state monitoring technology during high speed cutting. Based on different machining methods, machining quality, machining efficiency and tool life, obtain the cutting coefficient of typical workpiece material for the aerospace and power generation equipment, automobile manufacturing field, proposes the classification and evaluation system of workpieces material of high speed cutting, establishes the experimental test system using the comprehensive evaluation of the cutting tool performance and machining quality, and develops the database of cutting tool and cutting process for the typical difficult-to-cut materials.

Carry out method of the tool geometry precision design and high reliability design, strengthening and fine design analysis of cutting tool edge, build the precise digital design platform, develops the new structure special compound tool of high efficiency drilling CFRP, and CFRP/ titanium alloy laminated structure, and propose intelligent forecasting technique tool life model and self-adaptive high efficient drilling process.

Study on design and manufacturing technology the metal cutting tool ceramic of nano TiCN of non-bonded phase and its dry cutting mechanism. Research high speed cutting performance of cutting tool having surface micro texture of the non-bonded phase, establish the relation model of tool surface micro texture, mechanical properties of materials and high speed cutting performance of cutting tools.

Microstructure and Corrosion Resistance of the AlTiN Coating Deposited by Arc Ion Plating

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Abstract: A new type of AlTiN coating containing about 29.13 at.% Al，16.02 at.% Ti and 54.85 at.% N was prepared by arc ion plating technology. The coating is composed of singular fcc-(Al, Ti)N phase, and has no hcp-AlN phase to be formed. Due to the high content of beneficial element Al, the hardness and effective elastic modulus of the coating are up to 33.9GPa and 486.1GPa, respectively. Electro-chemical test shows that the corrosion current density of the AlTiN coating is nearly one-sixth of the substrate, and the AlTiN coating possesses a larger capacitive resistance than the substrate, which means that the coating could act as a protective barrier between the substrate and corrosive electrolyte, enhancing the corrosion resistance.

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Keywords: AlTiN, microstructure, mechanical property, electrochemical property, arc ion plating

Microstructure and properties of the TC4 alloy layer strengthened by powder-mixed near-dry electrical discharge surface modification

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Abstract: In this work the electric spark deposition method was used to strengthen TC4 alloy surfaces under powder-mixed near-dry medium conditions. The results indicate that dense, well combined with matrix and cascade chrysanthemum petal-like microstructure was obtained, which the strengthening layer combine substrate well, and with increasing current, the grain size increase. It was found that the preferably performance of mcrohardness can be got when the current were 3.7A and 6.6A were about 899HV and 1039HV. There is significantly improve compared with the original alloy (about 312HV). XRD result displayed that TiC, TiB, B_8C, Al_3BC, $AlTi_3$ and Al_5Ti_2 phases were found in the strengthening layer in addition to α-Ti phase. The metastable phase of $Al_{3.3}Ti$ appeared, and the phase of Ti-Al intermetallic compound increased significantly as the curremt to 6.6A. The research of this paper has important significance in breaking the traditional electric spark strengthening technology and expanding the field of electric spark surface strengthening.

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Keywords: powder-mixed near-dry medium, TC4 alloy, microstructure, properties

Effects of boronizing process on the friction coefficient and surface roughness of aisi 02 and h11

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ABSTRACT

In this study, the effects of boronizing treatment on material's dimensional changes, friction coefficient and surface roughness were investigated. The AISI 02 and H 11 were chosen as substrate materials. The boronizing treatments were performed in a mixture of KBF_4, B_4C and SiC at temperatures of 900°C, 950°C 1000°C during 2, 4, 6 and 8 h. On the surface of each steel, a monophase layer of Fe_2B. Experimental results revealed that longer boronizing time resulted in thicker boride layers. Optical microscope cross-sectional observation of the borided layers revealed denticular morphology. Boronizing treatment had also a significant effect on surface roughness of materials measured by Mitutoyo surftest SJ 301. The friction coefficient is measured by Tribometer CSM instruments (bille-disque)

Keywords: Boronizing; Hardness; Borides; Tool steels; surface roughness; friction coefficient.

Properties of pulsed-DC sputtered Cr-B-N films as a function of their boron content

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Transition metal boron nitrides are promising materials for protective coatings due to their ability to combine high hardness, good tribological properties and improved oxidation resistance. Few studies, mainly focused on boron-rich films, have been performed on Cr-B-N coatings.

The aim of the present study is to investigate the role of the boron content on the structural features of Cr-B-N films elaborated by pulsed-DC sputter deposition of 3 targets $Cr_{80}B_{20}$, $Cr_{60}B_{40}$ and CrB_2 in various Ar/N_2 mixtures. Compositions were assessed by EPMA and XPS with good accordance. The microstructure of the films was determined by combining XPS, XRD, TEM and FTIR. Mechanical properties of the films have been measured by nanoindentation. Oxidation tests were performed in air up to 700°C and the structure of the resulting films have been analysed by XRD and *in-situ* FTIR.

The present work reveals that with an increase of the nitrogen content, the films elaborated from a $Cr_{80}B_{20}$ target showed a transition from an amorphous to a nanocomposite structure that comes with a hardness increase. No marked change in the nc-CrN/a-BN nanocomposite structure was evidenced after oxidation treatment. Conversely, the films synthesized with higher boron contents were X-ray amorphous and showed a hardness drop and a depreciated high temperature oxidation resistance. This study emphasizes that the boron concentration is a critical parameter in the optimisation of the properties of Cr-B-N coatings.

TEXTURED GROWTH OF AlN FILMS DEPOSIDED ON Si(100), Si(111) and Pt(111) SUBSTRATES BY DC REACTIVE MAGNETRON SPUTTERING

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Abstract:

The texture evolution of AlN films during growth is considered for different orientation substrates. AlN thin films have been grown on Si (111) and Si (100) substrates by DC reactive magnetron sputtering. For AlN films grown on Si (111), the fiber (0001)<uviw> can be considered as perfect with low dispersion less than 7.5° for plan (0001) and the texture is particularly marked. For AlN with Si (001) substrate, the fiber texture is less pronounced and more dispersed (≈ 12°) and also presents preferred orientations. The (10-11) and (10-12) FDPs confirm the presence of reinforcements on the (0001) fiber. The angles between these reinforcements are 60° and 120°. The observed asymmetry increases with thickness and could be connected to the angular differences between the AlN (0001) and Si (100).

Research on multi-layer printed circuit board high speed micro-drilling process and tools

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Abstracts:
Micro-drills with diameters of 0.1–0.3 mm were used to drill printed circuit boards (PCBs) with a highest spindle speed of 300 krpm. It was found that abrasion was the main mechanism controlling the deterioration of cemented tungsten carbide micro-drills. The aggressive rubbing by glass fiber broken chips and reinforcing fillers, and the diffusion of cobalt caused abrasive wear of the flank, the chisel edge, the rake face, and the minor flank of the micro-drills. Resin that was softened by cutting heat would adhere to the micro-drills, which decreased chip removal and the accuracy of hole location. Micro-drill wear was inclined to cause nail heads and decrease the accuracy of hole location.