

INTERTECH 2011 - ABSTRACTS/PAPERS SUBMITTED*

**As of March 1, 2011... Additional Papers may also be considered after this date*

INTERTECH Paper - 1110

Barbara S. Linke Dr.-Ing.

WZL of RWTH Aachen University - Germany

TITLE: SELECTION OF GRITS IN ABRASIVE TOOLS – ONE WAY TO SUSTAINABILITY

ABSTRACT: Despite the growing awareness of environmental problems, there are still a lot of gaps in the evaluation of process eco-efficiency and material effectiveness. Especially in machining processes, challenges can often be met by the appropriate choice of tools. The selection of abrasive grits in abrasive processes is crucial for tool production and tool performance including wear behavior. The huge market of abrasives intensifies the grinder's difficulty of choosing the appropriate grit type. Moreover, often only insufficient data about the performance of the abrasives is available. Therefore, this work reviews relevant grit characteristics. Different methods for grit selection based on these properties are at hand; however, not all methods are appropriate for every grit type. So a thorough discussion is carried out emphasizing the aspects of resource and energy efficiency. Defined grit characteristics are a need for sustainable grinding tools. However, only the targeted layout of the complete system of grits, bond and pores results in outstanding abrasive tools and machining processes as a consequence.

INTERTECH Paper - 1111

Prof. Taghi Tawakoli

Institute of Grinding and Precision Technology (KSF) - Germany

TITLE: INFLUENCE OF GRINDING WHEEL HUB MATERIAL ON THE HIGH EFFICIENCY DEEP GRINDING (HEDG) PROCESS

ABSTRACT: High efficiency deep grinding (HEDG) combines the advantages of both creep feed and high speed grinding processes. HEDG is accompanied with high cutting speeds and feed rates and large depth of cuts. These cutting conditions enable extremely high material removal rates and reduce heat partition into the workpiece. Furthermore, HEDG results in an improvement of the grinding process in terms of tool wear, specific grinding energy and ground surface quality. The high efficiency grinding process has only been made possible by excessively rigid grinding machines, appropriate grinding tools and coolant supply system. The proper selection of grinding wheel can have a great potential in the optimization of the HEDG process as well as an important influence on the ecological and economical advantages of the process. The presented paper deals with comparing of two grinding wheels with different hub materials, namely CRFP (Carbon fiber-reinforced polymer) and steel, utilized in HEDG process. The experimental results show that the material removal mechanisms and process output parameters can be influenced by dynamic conditions of the grinding wheel which is influenced by hub material. The results demonstrate that the conditions of dynamic contact zone can be optimized by the mechanical properties of the hub material.

INTERTECH Paper - 1112

Xing Sheng Li, Research Leader

CSIRO - Australia

TITLE: EVALUATION OF MICROSTRUCTURE, WEAR CHARACTERISTICS AND CUTTING PERFORMANCE OF DIAMOND COMPOSITE TOOLS

ABSTRACT: The use of diamond composite tools has, over recent years, become widely accepted across many mining, exploration, manufacturing and processing industries. To fabricate a diamond composite tool, diamond grits are mixed with power of bond, pressed into a shape, and hot-pressed at elevated temperature. The principal factors that determine performance of diamond composite tool are the

composition of diamond composite tool, the operating parameters and the characteristics of the material being cut. Generally speaking, four major components determine the composition of diamond composite tool: (1) the diamond quality; (2) the diamond grain size; (3) the diamond concentration; and (4) the bond characteristics. The objective of this work is to gain a better understanding of the influence of diamond concentration on the microstructure, wear characteristics and cutting performance of diamond composite tools.

A series of wear and rock cutting tests were undertaken using diamond composite tools with different diamond concentrations. The wear tests were conducted on a wear testing rig in which a rotating aluminium oxide grinding wheel is turned by the testing tool element. The rock cutting tests were performed on a linear rock-cutting planer. The thrust and cutting forces acting on the tool were measured during these tests. The wear coefficients were used to evaluate wear characteristics while cutting performance was assessed by tool wear and the rates of increase in forces with cutting distance. The microstructure of diamond composite tools with different diamond contents was investigated by scanning electron microscopy.

A significant improvement in wear resistance and cutting performance were observed as the diamond contents increased. Correlations between microstructure, wear characteristics and cutting performance have been discussed.

INTERTECH Paper - 1113

Dr. Janusz Konstanty

AGH-University of Science & Technology - Poland

TITLE: NOVEL FE-NI-CU-SN MATRIX MATERIALS FOR THE MANUFACTURE OF DIAMOND-IMPREGNATED TOOLS

ABSTRACT: The main objective of the present work was to determine the effect of powder composition on microstructure and properties of iron-base nickel containing materials used as matrices in diamond impregnated tools. Various combinations of carbonyl iron, carbonyl nickel and pre-alloyed bronze powders were mixed and consolidated to a virtually pore-free condition by hot pressing at between 850 and 900°C. The specimens were then subjected to density measurements and tested for hardness, bending properties and resistance to abrasive wear. Their structure was examined by the light microscopy, scanning electron microscopy and X-ray diffraction. In the as-consolidated condition the examined materials showed a fine-grained microstructure and contained a high volume fraction of metastable austenite. As a result they exhibited high hardness, yield strength and excellent resistance to abrasion thus becoming good candidates to substitute cobalt in various diamond tool applications.

INTERTECH Paper - 1114

Hee-Sub Park

ILJIN diamond Co. Ltd. - KOREA

TITLE: MICROSTRUCTURE CONTROL AND MECHANICAL PROPERTIES OF CUBIC BORON NITRIDE NANOCOMPOSITE

ABSTRACT: During the solid state sintering of cBN and ceramic binder materials, it is difficult to uniformly distribute the binding material over the entire surface of every cBN particle. This often results in an inhomogeneous microstructure that either has portions lacking binder additives or portions where binding materials are segregated.

In this study, fabrication process and characterization of cBN nanocomposite made of cubic boron nitride which was coated with nanocrystalline TiN were investigated. Coating of the binder material on the surface of each cBN particle was tried to improve the microstructural homogeneity and to minimize the cBN-cBN contact in the final sintered compacts.

INTERTECH Paper - 1115

Woo Sung Kim

ILJIN diamond Co. Ltd. – KOREA

TITLE: MACHINING PERFORMANCE AND MECHANICAL PROPERTIES OF SOLID TYPE PCBN (POLYCRYSTALLINE CUBIC BORON NITRIDE)

ABSTRACT: Several grades of solid type PCBN with better productivity and various application areas have been developed. This paper presents the investigation results of physical properties and mechanical performances of new solid PCBN. Grade A, solid PCBN with high cBN content, suitable for cast iron machining and Grade B and C, solid PCBN with low cBN content, targeting hardened steel machining has been investigated.

Physical properties, density and TRS, of the new grades were measured and machining tests were carried out under various conditions. Other PCBN grades were tested to compare the performances with the new grades.

INTERTECH Paper - 1116

Jeffrey A. Badger

The Grinding Doc Consulting - USA

TITLE: INVESTIGATION OF THE WEAR RATES AND WEAR MECHANISMS OF VARIOUS CVD AND NATURAL DIAMOND

ABSTRACT: Chemical Vapor Deposition (CVD) diamonds are increasingly being used as single-point dressing tools for in grinding. Because they are composed of numerous, small crystals, they are largely anisotropic compared to natural-diamond tools, resulting in more consistent dressing performance. This study investigates the wear rates and wear mechanisms of various CVD and natural diamond, including the wear rates on the (100), (100) and (110) planes along with the respective directions within these planes. Diamond wear rates were also measured for different coolant conditions and for conventional Al2O3, Norton SG ceramic grit and Norton Quantum ceramic grit.

INTERTECH Paper - 1117

Philippe van Bogaert, CEO

Bogimac nv-sa – Belgium

TITLE: IMPROVEMENTS TO THE REQUIREMENTS OF THE FRIABILITY TEST METHODS ARE SUGGESTED, NARROWING THE DEVIATION ON THE RESULTS

ABSTRACT: The friability test as defined by the ANSI B74-23 is a very common test to validate the quality of meshed abrasives. Detailed test validations have been done correlated to simulation data, to better understand the conditions that can affect the test. Based on this research, improvements to the requirements of the test method are suggested. The following aspects help narrowing the deviation on the results, and thereby improves the relevance :

- impact energy and stroke-speed related stability
- influence of static electricity
- mechanical requirements of the test equipment on backlash & overall vibration
- cycle based versus time based reporting
- speed versus stroke calibration
- endcaps correct pre-conditioning and disposal state observation based on the rebound method
- impact angle fingerprint
- interest of vertical versus horizontal test method for subsieve types
- effect of impact ball and end caps geometry, material and surface quality
- wizzard with non-linear interpolation method for faster results, based on historical data for a pursued quality

INTERTECH Paper - 1118

John Wang, Associate Professor
University of Nevada Las Vegas - USA

TITLE: ARE HPHT DIAMONDS GOOD TOOL MATERIAL FOR PRECISION CUTTING?

ABSTRACT: In recent years, HPHT Single Crystal Diamond (SCD) is rapidly replacing natural diamond as precision cutting tool material in industry. This paper studies HPHT diamond's mechanical property with hydrostatic weighing, optical microscope, SEM, EDS, Raman spectroscopy, and XRD analyses. It reveals that HTHP diamond has lower density (3.396 - 3.452 g/cm³) than its natural peers (3.52 g/cm³) in our test, its residual stress is compressive and is in the range of 4.52 - 4.59GPa, which could be desirable as a cutting tool material. SEM study shows that HPHT diamond is 96.15% of carbon and 3.85% of oxygen by weight, or 97.08% carbon and 2.92% oxygen by atom. Both Raman and XRD tests further confirm the samples are high quality diamond with no graphite inclusions. Surface analysis with optical and SEM microscopes reveal numerous pit holes on HTHP SCD surface and multiple bubbles are visible inside the crystal, which are signs of defects. Formation and dissolution of Fe₃C phase in an HPHT reaction cell is believed to be critical to diamond growth and also to diamond defect development.

INTERTECH Paper - 1119

Mr. Gerhard Weber
Dr. Fritsch - Germany

TITLE: IMPROVING THE LASER WELDING OF DRILL BITS

ABSTRACT: Laser welding of drill bits is state of the art in the construction industry. This paper shows the impact of new production technologies on the welding strength and how to improve therefore the safety of the tool. In the meantime, the production costs are reduced significantly due to faster production time and much faster set up time. In the past, the strength of a laser welded joint was relying heavily on the geometrical tolerances of the tube and the diamond segment. A new measuring system automatically optimises the welding position in 3 axes to give always the optimum welding strength and makes the tool producer more independent of the tube supplier. This paper expands on the test and measurements that were taken out to improve the tool strength.

INTERTECH Paper - 1120

Mike Hitchiner, OEM Technology Manager
Saint-Gobain Abrasives - USA

TITLE: INCREASED PRODUCTIVITY IN THE CENTERLESS GRINDING OF PCD BUTTONS THROUGH A COMBINATION OF ADVANCED MACHINE TOOLS AND INNOVATIVE WHEEL TECHNOLOGIES

ABSTRACT: A major cost in the finishing of PCD buttons for energy exploration and cutting tool manufacturing is the centerless grinding of the raw PCD furnace product (including carbide support backing) using resin bond diamond wheels. Historically, G Ratio values have been limited to less than 0.015! This paper reports dramatic improvements to this process by utilizing the latest in centerless grinder design in combination with recent advances in diamond wheel technology. By taking such a systems approach, and applying it to the Landis Viking Grinder with a new hybrid wheel technology from Saint-Gobain Abrasives, it has proved possible to triple both the G Ratios and the Material Removal Rates, while eliminating stick dressing and allowing for the potential to automate the process. These improvements are expected to create significant, if not industry-changing, cost reductions for the manufacturers of PCD buttons.

INTERTECH Paper - 1121

Rahul Chaudhari, Manager, Machining and Finishing

The Timken Company - USA

TITLE: THE EFFECTS OF PCBN TOOL WEAR ON CUTTING FORCES AND SURFACE INTEGRITY IN FINISH HARD TURNING

ABSTRACT: The effects of PCBN tool wear on cutting forces and surface integrity in finish hard turning are investigated. The thrust force accelerates as tool flank wear exceeds a certain amount. Increased flank wear results in tensile residual stress at surface and reduces the magnitude of compressive stress below surface. However, very large flank wear yields maximum compressive residual stress below surface. A new tool life criterion is proposed for finish hard turning considering surface integrity.

INTERTECH Paper - 1122

Dr. Andre BATAKO

Liverpool John Moores University - UK

TITLE: NEW DEVELOPMENTS IN HIGH EFFICIENCY DEEP GRINDING

ABSTRACT: High Efficiency Deep Grinding (HEDG) has been known to secure high removal rates in grinding processes with high wheel speed, relatively large depth of cut and moderately high work speed. High removal rates in HEDG are associated with very efficient grinding and secure very low specific energy comparable to conventional cutting processes. Though there exist HEDG-enabled machine tool, the wide spread of HEDG has been very limited due to its requirement to the machine tool and process design to secure the work-piece surface integrity. HEDG is an aggressive machining process that requires an adequate selection of grinding parameters in order to be successful within a given machine tool and workpiece configuration.

This paper presents a progress made in the development of HEDG specialised machine tool. Results from HEDG processes obtained from the design machine tool are presented to illustrate achievable high specific removal rates. Specific grinding energies are shown alongside with measured contact arc temperatures. An enhanced single-pole thermocouple technique is used to measure the actual contact temperature in deep cutting. The performance of conventional wheels is depicted together with the performance of CBN wheel obtained from actual industrial tests.

Keywords: Grinding temperature, machine tool, HEDG, Grinding energy, wheels, G-ratio.

INTERTECH Paper - 1123

Boris A. Eizner, Director

A. Termika Ltd. - Israel

TITLE: TECHNOLOGY AND EQUIPMENT FOR THE MANUFACTURE OF DIAMOND GRINDING WHEELS OF THERMAL SPRAY COATING.

ABSTRACT: Our firm has developed a technology which allows applying the diamond-containing layer of diamond grinding wheels by thermal spray method. Layer is deposited by the HVOF or FS methods from a powder mixture of diamond and Bond. In this case, diamond powder is a special pre-processing. Our technology allows us not only to produce new diamond grinding wheels, but also to restore worn-out. Operation recovery wheel can be made on a simple lathe. We offer special portable equipment HVOF and FS with the help of which you can restore the wheel on any plant. In his report, we demonstrate the technological aspects of the recovery of diamond grinding wheels and making new ones. The same characteristics are designed for this equipment.

INTERTECH Paper - 1124

Nobuhide Nakamura

A.L.M.T. Corp. - Japan

TITLE: DEVELOPMENT OF PRECISION FIXED-DIAMOND WIRE PWS.

ABSTRACT: In this study, the features of two types of fixed-diamond wires, electroplated PWS-E and resin bonded PWS-R, are introduced along with case examples of slicing sapphire and silicon ingots. While global warming and energy depletion problems are getting serious, light-emitting diodes and solar cells are attracting attention as eco-friendly products. These devices utilize sapphire and/or silicon substrates which are sliced from ingots by multi-wire sawing. The explosive increase of the production of these devices accelerates the transition of sawing system from conventional loose abrasive type to fixed abrasive type, which has advantages of high efficiency, high precision and less industrial waste.

In this study, the features of two types of fixed-diamond wires, electroplated PWS-E and resin bonded PWS-R, are introduced along with case examples of slicing sapphire and silicon ingots.

INTERTECH Paper - 1125

Radu Pavel, Machining/Grinding Research Engineer

TechSolve Inc. - USA

TITLE: OPTIMIZATION OF CREEP FEED GRINDING OF NICKEL-BASED ALLOYS FOR QUALITY PRODUCTION

ABSTRACT: Nickel-based super-alloys are extensively used in military, aerospace, missile and defense applications with the aim of improving performance, life, and fuel efficiency. Creep-feed grinding is extensively used for final finishing of these components. The work presented in this paper is part of the efforts to develop a knowledge-based system approach to design and optimize the creep-feed grinding process, specifically focusing on nickel-based super-alloy as the work material. The paper presents the process optimization scheme and the first results of the experimental and modeling work conducted according to the proposed methodology. A CNC surface grinding machine has been instrumented to allow process monitoring and data collection including grinding forces, power, vibration, and acoustic emission. Surface finish, wheel wear, and residual stresses have been also collected for modeling purposes. The results obtained for two nickel-based materials ground using a ceramic grinding wheel are presented. One of the advantages of this method is that the models can be determined from a minimal number of experiments.

INTERTECH Paper - 1126

Li Zhihong, General Secretary

IDA China, Zhengzhou Research Institute for Abrasives & Grinding - China

TITLE: CHINA'S DIAMOND IN THE WORLD MARKET

ABSTRACT: China becomes the biggest producing country of synthetic diamond in the world. China's output in 2010 is in excess of 7 billion carats. The average increase rate is nearly 20% for the last 10 years, it almost accounts for 90% of the world's production. China's diamond is exported to 58 countries and regions in 2009. The average export increase rate is about 30% for the last 10 years. Two main reasons supported such growth: 1) Continuous improvements made to the diamond synthesizing technology and as a result quality becoming better and better and to a large extent Chinese diamond is close to or equal to those made by her Western counterparts in terms of quality. 2) Competitive prices. The average price is only about \$0.05 per carat in 2009, making it irresistible for world users to turn to Chinese diamond. Diamond producers in the Western countries turn to produce more profitable products like PCD & PCBN. This paper delivers some key statistics of Chinese diamond output and export in the last 10 years; it also highlights the diamond import in USA and Japan. The USA is the biggest consumer of China's diamond. The supply & demand pattern for synthetic diamond is very much different from what it used be 10 years ago. All these facts are further illustrated by the 10 figures and 1 table in this paper.

INTERTECH Paper - 1127

James C. Sung, President

KINIK Company - Taiwan, R.O.C.

TITLE: THE CMP BY POLISHING WITH GIP DRESSED BY BODD

ABSTRACT: Due to the continual improvement of CMP technologies, and the need for polishing delicate wafers at high speed, graphite impregnated pads (GiP) dressed by brazed organic diamond disks (BODD) can double the throughput of wafer-pass at the reduced cost of ownership (CoO). The increased polishing rate is due to the act of nano graphite particles that absorb slurry. The nano graphite particles coated with chemical and abrasive can achieve high removal rate without causing scratches on the wafer. In addition, nano graphite particles do not stick to wafer surfaces, so they can be cleaned easily. BODD can uniquely dress GiP to create slurry channels so the pore free pad is not bottlenecked by slurry supply. This paper also demonstrated the low stress polishing by applying ultrasound during the CMP process.

INTERTECH Paper - 1128

James C. Sung, President

KINIK Company - Taiwan, R.O.C.

TITLE: DIAMOND ISLANDS WAFER FOR SUPER LED MANUFACTURE

ABSTRACT: Diamond's (111) face can grow epitaxial GaN with wurtzite structure. Better still, single crystal AlN can be deposited directly on such diamond surface. Boron doped diamond has the highest mobility of holes, and silicon doped AlN can boost electron mobility. The AlN on diamond is capable to emit ultraviolet (UV) light with high intensity. Such UV light can excite phosphors for the emission of different colors, including white light with balanced RGB distribution. There are many possibilities of making super LED with diamond. Unfortunately, diamond wafers are not available commercially. However, synthetic diamond crystals can be made cheaply by a novel seeding technology (DiaCan™). These diamond crystals are embedded in a ceramic matrix to form diamond islands wafer (DIW). DIW is the enabling substrate for making super LED in the near future.

INTERTECH Paper - 1129

Hsiao-Kuo Chang

National Cheng-Kung University - Taiwan, R.O.C

TITLE: THE GLASS ROLLER CUTTER MADE OF CVD DIAMOND FILM

ABSTRACT: Diamond roller Cutters have been used to cut glass panels (e.g. for TFT-LCD). Typically, a sintered polycrystalline diamond disk is used as the cutter. The roller cutters may compress the glass and induce microcracks. Subsequently, the glass panel can be bent to break along these microcracks. In order to concentrate the stress to initiate the microcracks, the edge of the diamond roller cutters is often traversed by a diamond wheel to form serrate cutting teeth. In this research, we fabricated diamond wheel cutters by using CVD diamond films. The results indicated that the diamond film was a viable substitute of sintered polycrystalline diamond for cutting glass. The diamond film wheel cutters may be mass produced for commercial applications.

INTERTECH Paper - 1130

Alfred Trenker, President

TRENKER ABRASIVE PLANT TECHNOLOGY - GERMANY

TITLE: APPLICATION AND MANUFACTURING OF ELECTROPLATED TOOLS WITH SUPER-ABRASIVES FOR THE SEMICONDUCTOR AND SOLAR INDUSTRY

ABSTRACT: Application and manufacturing of electroplated tools with super-abrasives for the semiconductor and solar industry

- Overview: Tools for cutting, dicing, polishing and slicing
- Dicing blades with aluminium hub
- Dicing blades without aluminium hub
- Plating technology dicing blades
- CMP conditioner pads for oxide and metal wafer processing
- ID saw blades
- Diamond band saws
- Band saw plating equipment
- Diamond wire saw
- Diamond wire saw machines
- Fully automatic electroplating diamond wire manufacturing equipment

INTERTECH Paper - 1131

Don Cutchall, Senior Applications Engineer

Winterthur Wendt USA - USA

TITLE: CHARACTERIZATION OF VITRIFIED CBN GRINDING WHEELS FROM A THERMAL PERSPECTIVE IN CAM GRINDING

ABSTRACT: With applications in grinding of hardened steel, it is a challenge to properly select and apply vitrified CBN wheels to avoid thermal damage while maintaining high stock removal rates. Although much progress has been made in this area in cylindrical grinding, in regards to cam grinding, this endeavor has until recently been elusive. In the past, standard calculations used for cylindrical grinding such as length of contact and stock removal have been improperly applied to cams. This paper will present the proper cam geometry and its use with a standard Jaeger thermal model. With the proper application of the math, a method for deriving critical wheel parameters essential to the thermal model will be presented. Consequently, this has led to better wheel specifications and designs.

INTERTECH Paper - 1132

Matthias Martin, Product Manager

Wendt GmbH Winterthur Technology Group - Germany

TITLE: FINEGRINDING DEVELOPED AS A PROVEN PROCESS COMPARABLE WITH LAPPING TO FINISH HIGH PRECISION WORKPIECES

ABSTRACT: Since many years finegrinding with lapping kinematics is being used to finish high precision workpieces in double side grinding processes. Today small and large batches of hard materials and hardened steel parts can easily be ground on these machines with superabrasive wheels.

In industry through feed face grinding machines are being used to rough grind parts before finishing them on finegrinding machines. Typical market requirements in flatness, parallelism and surface roughness Rz are below 2 µm. Exact for these applications finegrinding has been developed and in the meantime it is a proven process comparable with lapping in respect of surface quality. Finegrinding is even remarkable in respect of its cool grinding and low surface damage. In addition actual machine developments with more powerful drives and higher speeds allow rough and finish grinding on one machine with identical grinding wheels.

INTERTECH Paper - 1133

Dan Belnap, PhD

Megadiamond, a Schlumberger Company - USA

TITLE: STUDY OF THE INFLUENCE OF COBALT CONTENT ON POLYCRYSTALLINE DIAMOND (PCD) MECHANICAL PROPERTIES

ABSTRACT: Polycrystalline diamond (PCD) has distinct advantages in mechanical properties over traditional engineering ceramics, i.e., comparatively high strength and toughness. Also, the extreme high wear resistance makes PCD an indispensable material for gas/oil drilling and mining applications, as well as in high precision cutting tools. Pushing the limit of the material performance boundary of PCD is in many cases the key to success in these applications. In this study, a model PCD material system is investigated using the standard PCD manufacturing technology in the diamond stable region by varying the content of the secondary catalyst metal phase. The influence of the metal content to PCD mechanical properties as well as wear resistance is discussed.

INTERTECH Paper 1134

Smirnov Evgeny, Head of Laboratory

Nanoengineering - Russia

TITLE: NANOTECHNOLOGY FOR MANUFACTURING ULTRATHERMOCONDUCTIVE COMPOSITE MATERIALS

ABSTRACT: Nanotechnology for synthesis of composite materials with ultrahigh thermoconductivity is developed. Thermoconductive composite materials are made of industrial diamonds bound in metallic matrix. The size of diamonds and the nature of matrix can vary depending on the product application. Thermoconductive composite materials can be used for making high-effective heat conductors and radiators in electronic and powerful laser devices. The heat conductivity is no less than 900 Watt/m*K (compare to 390 Watt/m*K in case of Cu and 270 Watt/m*K in case of Al) and density is ~5.5 g/cm³.

INTERTECH Paper - 1135

Matt Huff, Product Specialist

Cinetic Landis Corp. - USA

TITLE: CONVERTING FROM CONVENTIONAL TO SUPERABRASIVES

ABSTRACT: This paper covers the topic of converting conventional abrasives to superabrasives, more specifically detailing how to justify the conversion financially and then how to go about the actual conversion.

INTERTECH Paper - 1136

Kuen-Liang, Chang, Master

National Taipei University of Technology - Taiwan

TITLE: LARGE GRAPHITE FILMS EVOLVED FROM MOLTEN METAL CATALYST

ABSTRACT: Graphene is the ideal material for many dream applications, such as single electron transistors, field emission sources, light through electrodes, flexible solar cells, wall paper displays, UV light emitting diodes, atomic gas sensors, DNA or antigen wafers, terra hertz surface acoustic wave (SAW) generators and filters...etc. However, a practical method to fabricate meter-sized graphene is still beyond imagination. In this research, we reported a simple technology to harvest large area graphite films by using molten alloy as the catalyst. Each film contains hundreds or thousands layers of graphene. Some stacks of graphene revealed silk-like tenderness with transparent folding lines. This liquid phase epitaxy (LPE) process appears scalable for making graphene layers measured in meter size. This paper also presented many intriguing aspects related to the growth of large graphene.

INTERTECH Paper - 1137

William Russell, Senior Development Engineer
Diamond Innovations - USA

TITLE: IMPROVED MACHINING OF NON-FERROUS METALS UTILIZING A NEW FINE GRAINED PCD

ABSTRACT: A new fine grained PCD has been developed that provides improved toughness, reduced friction and increased sharpness of cutting edges for turning and milling of non-ferrous alloys. A machining study has been conducted on Ti-6Al-4V material with the new grade and several standard competitive PCD grades. The new PCD grade also shows advantages in improved surface finish in turning and enhanced toughness in aluminum milling. Results of the testing will be reviewed along with metallographic analysis relating surface morphology and surface chemistry to the tool performances.

INTERTECH Paper - 1138

Raja Kountanya, Senior Development Engineer
Diamond Innovations - USA

TITLE: A COMPUTER MODEL FOR WORN CUTTING EDGE IN HARD TURNING

ABSTRACT: Past machining research employed 2D rationalization of complex 3D phenomena. Advancements in topographic and pictographic characterization of cutting tools along with flexible software platforms now allow a complete 3D construction. Synthesis of these tools opens new horizons in product and application development in hard turning. The paper describes how a general 3D model for a corner-radiused, chamfered, edge-honed cutting tool was formulated in Mathematica®. For given geometric parameters and cutting conditions, the angular extremities of contact on the corner radius and leading/trailing edges was obtained and validated. Notwithstanding the 3D orientation of the cutting tool, the simulated surface finish results agreed with well-known trends from 2D modeling. The theoretical surface finish topography including the Brammertz and sideflow effects was obtained in typical hard turning. Results compared favorably with that in literature. The model was expanded to allow wipers and flank wear. A simplified crater wear model was adopted for continuous hard turning to allow virtual cross-sectioning. Accurate estimation of flank and crater wear volume was also enabled. A case-study of using the model to improve performance in superalloy machining is shown.

INTERTECH Paper - 1139

Thomas Easley, Senior Development Engineer
Diamond Innovations - USA

TITLE: PROPERTIES AND PERFORMANCE OF HPHT PROCESSED DIAMOND-SiC COMPOSITES

ABSTRACT: Research into the production and uses of SiC bonded diamond composites dates to as early as 1977. Early attempts explored hot isostatic pressing, HPHT, and vacuum infiltration processing routes. Recent improvements in HPHT manufacturing techniques facilitate the production of high diamond content, fully dense, and defect-free microstructures with significant improvements in strength, abrasion resistance, and fracture toughness compared to historical materials. The composites are produced as large, electrically conductive billets from which a wide variety of product shapes and sizes can be easily produced. This paper presents a study of the relationship between microstructure and material properties. SEM, XRD, flexure strength, fracture toughness, erosion resistance, thermal and electrical properties will be presented.

INTERTECH Paper - 1140

Sridhar Kompella, Mesh Applications Technology Manager

Diamond Innovations - USA

TITLE: SYSTEM COST REDUCTION IN TUNGSTEN CARBIDE INSERT GRINDING

ABSTRACT: Cemented tungsten carbide tools routinely undergo a finish grinding process to achieve the desired dimensions and tolerances. Among part quality attributes, visual thermal damage ('burn') or chipping of the tool edges are unacceptable. Optimizing such a grinding process necessitates meeting a cycle time constraint to match production with available capital equipment while ensuring the lowest system cost. In this paper, we examine a production process to grind the periphery of inserts and report that even in a well-established process; the grinding parameters can be modified to improve cycle time by 17%. Choosing a superior diamond-bond system results in a 25% cycle time improvement over the baseline. In assessing the system cost, it is found that cycle time is the biggest contributor, outweighing the cost of labor and consumables. An efficient tool grinding process not only lowers the cycle time, it translates to an effectively expanded capacity and reduced pressure on capital expenditure. Further, using a more efficient diamond-bond combination results in lower wheel and dressing cost per part, even if the up-front wheel cost is higher than with the baseline wheel.

INTERTECH Paper - 1141

Sridhar Kompella, Mesh Applications Technology Manager

Diamond Innovations - USA

TITLE: SUPERALLOY GRINDING PRODUCTIVITY IMPROVEMENT WITH NEW CBN CRYSTALS

ABSTRACT: The superior thermal properties of nickel-based superalloys that make them suitable for use in gas turbine blades and vanes also make them difficult to grind. Cubic boron nitride (CBN) crystals, which possess high thermal conductivity, lend themselves to superalloy grinding by dissipating the grinding heat more effectively than conventional abrasives. Even so, productivity is constrained by the propensity of superalloys to suffer thermal damage when using accelerated grinding parameters. Furthermore, the process economics hinge on maximizing grinding wheel re-profiling intervals and the overall wheel life. In this paper the performance of two novel CBN crystals in grinding Inconel 718 as function of the vitrified bonded wheel life, the workpiece surface characteristics, and the process energy requirements is examined. The significantly lowered cost per part and productivity delivered by these new CBN crystals is compared with the baseline process. Possible mechanisms to explain the performance of the new crystals are discussed.

INTERTECH Paper - 1142

Sridhar Kompella, Mesh Application Technology Manager

Diamond Innovations - USA

TITLE: SUPERALLOY GRINDING WITH ELECTROPLATED CBN WHEELS AND INFLUENCE OF MANUFACTURING QUALITY ON PERFORMANCE

ABSTRACT: Electroplated (EP) wheels utilizing coarse CBN particles are commonly used in rough grinding of superalloy components. A single layer of tough, blocky CBN crystals attached by a nickel layer enables high removal rates with little risk of thermal damage when using the appropriate setup. In this paper, the improved performance afforded by a new, tougher grade of CBN in superalloy grinding with EP wheels is discussed. The attributes of the new CBN that enable the enhanced performance are discussed. In addition, it was found that for non-dressable EP (or braze-bonded) CBN wheels, the metal layer uniformity, crystal protrusion, and the dimensional integrity of the wheel core play a critical role. Experimental results enumerating the influence of these factors are presented.

INTERTECH Paper - 1143

Dr. Baochang Liu, Associate Prof.

College of Construction Engineering Jilin University – China

TITLE: DIAMOND IMPREGNATED BIT ENHANCED WITH CVD DIAMOND PINS AND ITS DRILLING PERFORMANCE

ABSTRACT: The performance of diamond impregnated bit had great influence on the efficiency and cost of geological exploration drilling. To improve bit performance, a new type of diamond impregnated drilling bit enhanced with CVD diamond pins was designed and manufactured in this paper. The dimension and number of CVD diamond pins and their arrangement in the bit matrix were designed. The hardness of bit matrix, the size and concentration of diamond grit and bit structure were designed according to the drillability index and abrasiveness of the rock sample to be drilled. 1060;59mm diamond impregnated bits enhanced with CVD diamond pins were manufactured with the method of intermediate frequency hot pressing. Percussive rotary drilling tests using these bits were conducted. The drilling results indicated that the bits enhanced with CVD diamond pins demonstrated higher drilling efficiency and superior impact resistance compared with the bit inserted with soft pins (graphite). Compared with pure rotary drilling tests, the bits showed higher drilling efficiency (up to 2.84m/h) in percussive rotary drilling tests. In addition, the drilling process of the bits enhanced with CVD diamond pins was steadier than ordinary ones.

INTERTECH Paper - 1144

Steve Roffman, Vice President

Lieber and Solow Ltd. - USA

TITLE: NATURAL DIAMONDS TRENDS IN MINING AND MARKETS POSE INTERESTING CHALLENGES TO DEALERS, DIAMOND TOOL MANUFACTURERS AND ENDUSERS

ABSTRACT: The Natural Diamond Tool industry has faced many challenges over the past 50 years...

There were many predictions that man made products and new technologies would replace natural diamond tool products. However, for the last 50 years, the usage of natural diamonds by industry continues to absorb all of the available materials, as demands are constant and the tooling is relevant and necessary. Natural diamonds have been proven to be the product of choice for so many applications and we are certain, it is the best choice of material for these applications. Recently, there have been many changes on the supply side which have to be addressed by all users and suppliers. In this presentation we will address these changes, and discuss the ways our industry, from the dealers, to the tool manufacturers to the end-users are affected by these challenges and how we can all manage to successfully negotiate through these challenges and benefit from the opportunities which will exist.

INTERTECH Paper - 1145

Takeru Nakashima, Chief Engineer

Sumitomo Electric Hardmetal Corp. - JAPAN

TITLE: CUTTING PERFORMANCE OF BINDERLESS PCD FOR HIGH-PRECISION MICROMACHINING

ABSTRACT: Recently there has been an increasing need for high-precision micromachining of hard and brittle materials. However, using conventional PCD and single crystal diamond have their limits for these applications due to shortage of wear resistance and anisotropic wear, respectively. We have developed new superhard material; single-phase (binderless) polycrystalline diamond with ultrafine grain size (~50nm), which is suitable for this application due to extremely high hardness and no cleavage. In this presentation we will show the mechanical properties of new material and some examples of its performance in cutting cemented carbide and some kinds of optical ceramics. These results prove this material has an extremely high potential for this application.

INTERTECH Paper - 1146

Heiner Vollstädt, Professor
Vollstädt - Diamant GmbH - Germany

TITLE: X-RAY TOMOGRAPHY OF DIAMOND SYNTHESIS CORES

ABSTRACT: The quality and efficiency of the industrial diamond synthesis in the present days mainly depends on the exact knowledge of the complex process. The 3D X-ray scanning of the synthesis core has been used to demonstrate the different diamond growing stages. From the results can be derived the grain size distribution in the core, the diamond content in the different stages of growth, the spatial distribution of diamonds and to some extent the shape of the diamonds. The method and the different applications of the computer tomography equipment are described.

INTERTECH Paper - 1147

Joe Shebesta
Cutting Edge Services Corp -USA

TITLE: DIAMOND WIRE CUTTING SLOTS IN DAMS TO RELIEVE CONCRETE STRESS DUE TO ALKALI-AGGREGATE REACTIVITY (AAR) IN CONCRETE.

ABSTRACT: Based upon a recent project at Mactaquac Dam in New Brunswick using diamond wire saws to cut slots in the dam to relieve concrete stress. The Mactaquac Dam is an embankment dam used to generate hydroelectricity in the Canadian province of New Brunswick. It dams the waters of the Saint John River and is operated by NB Power with a capacity to generate 653 megawatts of electricity from 6 turbines; this represents 20 percent of New Brunswick's power demand. This paper will discuss stress due to AAR, and repair approaches using diamond wire saws on this dam and future repairs on similar structures stressed by AAR.

INTERTECH Paper - 1148

Dr. Manabu Iwai, Associate Professor
Toyama Prefectural University - Japan

TITLE: MATERIAL PROPERTY OF NEWLY DEVELOPED PCD MADE UP OF ELECTRICALLY CONDUCTIVE DIAMOND PARTICLES

ABSTRACT: Polycrystalline Composite Diamond (PCD) is manufactured by sintering fine diamond particles under high pressure and high temperature adding some quantity of cobalt as a catalyst (solvent), where diamond particles are strongly bonded with each other by intergrowth, thus it has properties of high hardness and chipping resistance at the same time. In addition, a large PCD disc having a diameter of 70mm is commercially available now. This makes it possible to respond to a requirement for large sized products. Though PCD is used mainly as cutting tools, wear resistant tools and wear parts, its application to a wheel for fine machining or a long lasting electrode for EDM (electro discharge machining) has been recently reported. For processing these PCD components, EDM or grinding technique is generally adopted. However in grinding, low machining efficiency and high cost have come to an issue, since the diamond wheel in use easily gets grazed because of the diamond contained in PCD at a rate of higher than 90%. Situation is the same with EDM, which means that only 10 % of cobalt contained makes it possible to process PCD by EDM, but with its unstable machining and low efficiency it is said to be difficult to achieve high quality machining. This is because the diamond particles themselves are electrically non-conductive. In order to cope with the above mentioned problems attached to PCD processing, it is essential to introduce a new PCD possessing excellent tool property and good machinability at the same time. Authors have succeeded in experimental manufacture of a unique PCD using boron-doped electrically conductive diamond in place of non-conductive diamond normally used for existing PCD. With an eye on the application of a unique PCD (EC-PCD, hereinafter) to various tools and mechanical parts, resistivity and thermal properties were investigated to gain an understanding of the EC-

PCD that was manufactured experimentally. As a next step, sliding wear characteristics of EC-PCD was investigated in the pin-on-disc experiment using a metal disc, and electrical discharge machinability was compared with conventional PCD. The result shows that the EC-PCD is superior in heat resistance compared with the conventional PCD. And the EC-PCD shows low frictional wear at high temperature in sliding test against stainless steel disk. Furthermore, it was found that the material removal rate and the surface roughness for EC-PCD were better than that of the conventional PCD in EDM experiments.

INTERTECH Paper - 1149

Dr. Manabu Iwai, Associate Professor
Toyama Prefectural University - Japan

TITLE: EFFECT OF COMPLEX GRINDING ASSISTED WITH EDM FOR ELECTRICALLY CONDUCTIVE PCD

ABSTRACT: Being composed of fine diamond particles (>90vol%) sintered together with cobalt as a solvent under high pressure and high temperature condition, Polycrystalline Composite Diamond (PCD) is excel in chipping resistance despite its very high hardness. However, it is not easy to EDM or grind PCD because diamond particles composing PCD are not electrically conductive and they are strongly inter-grown with each other. For instance in EDM, it is difficult to obtain high quality surface on PCD for the reason that material removal from diamond particles cannot be achieved by EDM. In addition, low efficiency and extremely large electrode wear are also problems here. In grinding PCD, use of diamond wheel is essential, but during the grinding, diamond abrasives contained in the wheel easily get grazed and rapid rise of grinding force results. To realize high efficiency and high quality processing of PCD simply and at low cost, it is thought to be indispensable to develop a processing technology based on a new idea, or to develop a new PCD possessing superior tool characteristics as well as good machinability at the same time. In this study, investigation is made on effective grinding method to realize “high efficiency”, “low and stable grinding force” and “low wheel wear” utilizing material characteristics of a new PCD i.e., EC-PCD (Electrically Conductive PCD) made up of electrically conductive diamond particles, manufactured for the purpose of realizing the PCD with superior tool characteristics and good machinability. To be more precise, Complex Grinding assisted with Electrical Discharge machining (C-EDG) where discharge machining and grinding are used in combination during material removal was applied to EC-PCD and grinding characteristics were investigated. As a result of investigation, we obtained the result as that lower and more stable grinding force is realized thanks to the material removal action in EDM and that lower wheel wear and better surface finish are attained, just when the EC-PCD is selected as a workpiece in the complex grinding.

INTERTECH Paper - 1150

Dr. Roger Nilen

Diamond Research Laboratory, Element Six (Production) (Pty) Ltd. - South Africa

TITLE: DIAMOND ENHANCED CARBIDE – A NOVEL ROUTE FOR MANUFACTURE

ABSTRACT: Diamond enhanced carbide (DEC) is a class of material that combines the wear resistance of diamond with the toughness of cemented carbide. The cemented carbide is typically WC/Co, i.e. WC with a Co binder phase, and the diamond content usually lies in the 10 – 50 vol% range. DEC therefore targets the performance middle ground between conventional hardmetals and ultra-hard materials such as diamond, polycrystalline diamond (PCD) and polycrystalline cubic boron nitride (PcBN). A novel 2-stage approach for DEC manufacture is presented in this paper. In the first stage, a diamond–WC/Co green body is sintered at low pressure–high temperature conditions during which the diamond is completely or partially graphitised by the Co, while the carbide matrix sinters around these graphite inclusions. In the second stage the resulting compact is re-sintered at high pressure–high temperature conditions, forcing the recrystallisation of the graphitised diamond back to diamond in the form of polycrystalline diamond–carbide (PCDC) inclusions. The abrasion resistance of DEC thus manufactured was found to be almost 20

times higher than the parent carbide grade in granite cutting. The diamond enhancement resulted in a 14% increase in Young's modulus with no significant loss of biaxial flexural strength. Furthermore, because the extent of graphitisation of the diamond during vacuum sintering is dominantly determined by the diamond grain size, several unique PCDC-based microstructural features can be engineered in the sintered body, some examples of which are also discussed.

INTERTECH Paper - 1151

Alex Schreiner

Business Development Manager

Synova - USA

**TITLE: MICRO-MACHINING AND CUTTING OF HARD MATERIALS USING WATER JET-
GUIDED LASER TECHNOLOGY**

ABSTRACT: The water jet-guided laser technology has found a broad range of applications in the micromachining field. Its principle is to focus a laser beam into a hair-thin, low-pressure water jet, onto the workpiece. This hybrid system prevents heat damage to the material by cooling the cutting edges in between the laser pulses; simultaneously the water jet removes the laser generated molten material. Contamination is avoided thanks to a thin water film covering the part surface during the cutting process. The perfectly cylindrical water jet yields highly parallel kerf walls. In this paper results from ceramic, cubic boron nitride, CVD and Diamond cutting will be presented. A 1064 nm infrared and 532 nm green laser are used from 2-20 kHz to process these hard materials. The use of the technology in the production of tooling bits and its advantages over diamond saw and grinding are discussed. In addition the cleaving of diamonds can be achieved with less material loss. Finally ceramics and related electronic materials can be machined with exceptional precision and quality. The technology presents a more cost effective method of processing the hard to machine materials and is being deployed by manufacturers worldwide to deliver the best tools inserts, most accurate ceramic parts and cleaved diamonds at lower cost. In the case of tool inserts the technology can reduce processing steps required to produce the final part. For the ceramic and diamond applications the high accuracy and very low heat affected zone (HAZ) allow for more accurate parts and less material loss.

INTERTECH Paper - 1152

Ion Benea Ph.D., Vice President Operation - Hyprez Products

Engis Corporation - USA

TITLE: SURFACE TEXTURED DIAMOND PARTICLES – PROPERTIES AND APPLICATIONS

ABSTRACT: Surface etched monocrystalline diamond particles were produced via a proprietary etching process (patent application). The surface etched mesh and micron size diamond particles, exhibit rougher surface, therefore increased surface area. When incorporated in bonded tools via mechanical and/or chemical bonding, surface etched diamond particles provide increased bond retention, compared to regular monocrystalline diamond particles whose surface is not altered. When incorporated in slurries and/or compounds for lapping and polishing applications, surface textured diamond particles, provide higher surface finishes and less random scratching. Furthermore, surface etched diamond particles, provide better powder packing and less breakage and chipping of corners and edges when compacted at high pressures during the high pressure – high temperature sintering of PCD (polycrystalline diamond compact) products.

INTERTECH Paper - 1153

David Slutz

Morgan Technical Ceramics - USA

TITLE: NEW CONCEPT CONDITIONER MADE BY AN ENGINEERED SURFACE COATED WITH CVD DIAMOND

ABSTRACT: CMP diamond conditioners by their nature impose a topography on the pad surface due to the cutting action of the diamond crystals. This topography is dependent on both the CMP process conditions, as well as, the type of conditioner used to condition the pad. This paper discusses the results that were obtained with four different CMP diamond pad conditioners. Three of the conditioners were typical diamond conditioners made with different diamond grit sizes, while the fourth is a new concept conditioner made by an engineered surface coated with CVD diamond and free of any diamond grit. Copper process data results for all four conditioners show an unexpected increase in copper removal rate for the new concept conditioner

INTERTECH Paper - 1154

Ana Lúcia Diegues Skury, Professor

State University of Northern Fluminense (UENF) - Brazil

TITLE: USE OF RECYCLED DIAMOND IN THE MANUFACTURE OF SAWS FOR CUTTING STONE

ABSTRACT: The consumption of diamond tools used in cutting and processing of natural stones, particularly of saws cutting, is very high. After the useful life the saw constitute scrapped material, and apparently no commercial value. However, studies have revealed that a significant amount of diamonds is still in the saws scrap. From this observation the group of superhard materials developed a methodology of economically viable and environmentally correct way to recycle and extract the diamonds from saws. The diamonds were then recycled for the manufacture of saws for cutting marble. The saws were used in cutting marble, and the efficiency of the saw, measured in linear feet cut off, was considered satisfactory. From the results obtained, together with the extraction technology developed can be said that the recycling of diamonds is an economically viable activity and should be implemented.

INTERTECH Paper - 1155

ANA LUCIA DIEGUES SKURY, Professor

State University of Northern Fluminense (UENF) - Brazil

TITLE: EVALUATION OF PERFORMANCE OF NANOSTRUCTURED CBN INSERTS IN MACHINING STEEL

ABSTRACT: The composites based on the cubic boron nitride (cBN) are highlighted in the machining of high hardness metals, which may replace the grinding. The effectiveness of using the cBN composites depends, in general, of the insert toughness. The present study shows results obtained during the performance evaluation of nanostructured cBN inserts produced by sintering at high pressures and high temperatures in the system cBN-Al-TiB₂. It was observed that the inserts produced from nanostructured materials have higher toughness than that observed in inserts produced from microstructured raw material. For the tests we used a ROMI machine with maximum speed of 2500 rpm, for fixing of the cutting inserts was used a tool constructed by the authors. The cutting parameters used for the tests and the criterion for end of life tools have been defined based in literature review, manufacturers recommendations and experience of laboratory personnel working with the machine used and a set cutting speed of 200 m / min, feed 0.2 mm / rev and cutting depth of 0.5 mm as a criterion for end of life for the cutting tools were used to flank wear a maximum of 0.3 mm.

INTERTECH Paper - 1156

Jerry Zimmer, CTO

sp3 Diamond Technologies - USA

TITLE: COMMERCIAL APPLICATIONS OF ELECTRICALLY CONDUCTIVE DIAMOND

ABSTRACT: Electrically conductive diamond has many possible applications in commercial products but success depends on not only growing diamond with the correct mechanical and electrical properties but also on maintaining the correct properties at the interface between the diamond and the substrate.

This paper explores the application areas enabled by conductive diamond films and the issues and tradeoffs in diamond properties which will determine the characteristics of the final product.

INTERTECH Paper - 1157

Ana Carolina Almeida Sá

Universidade Candido Mendes Campos - Brazil

TITLE: DISCRETE SIMULATION FOR ANALYSIS OF DIAMOND SAWS FOR STONE PROCESSING

ABSTRACT: Diamond Saws are tools used, nowadays, in all processes of transformation of ornamental stones, from the extraction of quarry block, passing by the sawing of the block, cutting, grinding and finishing in the polishing of the tiles. These are usually made of abrasive particles of varying sizes, embedded in the ceramic matrix (cement mortar) or in the polymeric matrix (polyester or epoxy). This study presents an analysis through computer simulation and experimental design of the manufacturing process of Diamond Saws, assessing the number of operators on processes, layout of machinery, production flow, among other important parameters to analyze the dynamics of the system and the operational rules. These parameters are important, in view of the deployment phase in which it is the ABRASDI, the Brazilian company for production of diamond tools, with technology genuinely national, seeking to maximize production, according to available resources.

INTERTECH Paper - 1158

David Egan, Senior Metallurgist

Element Six, Shannon Industrial Estate - Ireland

TITLE: THE USE OF ENCAPSULATION FOR DIAMOND TOOL MANUFACTURE

ABSTRACT: The encapsulation of diamond particles in a layer of metal bond material is known in the field. However, while it is acknowledged that encapsulated diamond can deliver improved tool performance over the blending of loose bond powders, the challenge to date has been to develop a commercially viable capability. The development of a new proprietary technology improves significantly on conventional techniques in its ability to deliver lower manufacturing costs and the ability to coat finer diamond particles. In addition, the capability now exists to coat particles with any bond material to any thickness. In this paper, we demonstrate the potential of a new capability for diamond encapsulation, in terms of uniformity of diamond particle distribution in the bond and the ability to engineer functional gradients within the bond matrix, both hard zones enveloping diamond particles or sandwich segments of varying diamond concentration. Such engineered bond structures are shown to provide for tool life improvements of up to 50%. Of particular interest for the production of single-layer tools, is the capability to economically produce air-brazable diamond abrasive which dramatically simplifies tool manufacture. The paper will outline the new degrees-of-freedom for economically enhancing the performance of diamond tools.

INTERTECH Paper - 1159

Stephen Kelly, Regional Technical Manager

Element Six US Corp. - USA.

TITLE: MACHINING TITANIUM ALLOYS WITH PCD

ABSTRACT: Demand for greater fuel efficiency is driving the development of aircraft manufactured from new, lighter weight and increasingly difficult-to-machine materials. Due to their high temperature strength and corrosion resistance, titanium alloys are becoming even more critical in the aerospace industry, particularly due to its compatibility with CFRP. Additionally, in biomedical applications, titanium alloys are being used more frequently given their excellent biocompatibility. There are distinct challenges to machining titanium parts economically and effectively. This paper will outline the potential for different PCD grades in machining titanium relative to carbide tools, the importance of using high pressure coolant and the role of titanium carbide layer formation on cutting tool wear. This paper aims to assist the toolmaker and machinist in successfully machining titanium alloys materials ensuring the aerospace industry continues to meet the demanding requirements placed on it in an increasingly competitive environment.

INTERTECH Paper - 1160

Peter Harden, Manager of Market Support Centre

Element Six, Shannon Industrial Estate - Ireland

TITLE: A NEW PARADIGM IN THE MACHINING OF WOOD AND COMPOSITE MATERIALS

ABSTRACT: Polycrystalline diamond (PCD) tools form an important part of the wood, wood containing and synthetic wood-like composites machining industry and currently account for between five and ten percent of this market with the remainder occupied predominantly by tungsten carbide (WC) tools. As a result of diamond's extreme hardness, PCD tools offer significant productivity benefits in wood machining over WC with tool lives typically 10 times longer or more. In the past, however, the uptake of PCD in these applications has been limited by its toughness which is lower than that of WC. Toughness is an important property in machining operations, particularly interrupted machining operations, and in the machining of wood most operations are of an interrupted nature. This paper describes a revolutionary new PCD material that doubles tool life by enhancing its impact resistance whilst at the same time retaining its extreme abrasion resistance. In addition to performance enhancements, this new material also incorporates design features that make tool fabrication more cost effective.

INTERTECH Paper - 1161

Cormac Lee, Applications Engineer

Element Six, Shannon Industrial Estate - Ireland

TITLE: NEW HIGH STRENGTH CBN ABRASIVE FOR SINGLE LAYER TOOLS

ABSTRACT: The demand for increased productivity and material removal rates constantly demands higher grinding speeds and feed-rates. Tougher CBN abrasives and stronger, often electroplated, wheels have been an enabler for modern grinding techniques such as high efficiency deep grinding (HEDG). Element Six has recently developed an extremely tough CBN abrasive for single-layer tooling applications. In this paper the performance of the new CBN abrasive in US mesh size 50/60 and 120/140 is assessed against four other commercially available CBN abrasives when high-speed grinding ductile cast iron. The testing was undertaken using near-HEDG conditions with electroplated wheels on EN GJS 700-2, a spheroidal graphite iron commonly used for automotive components. As a wear-rate or G-ratio value cannot be calculated for an electroplated tool as it can for impregnated bond tools, the end-of-life criteria was defined as the volume of workpiece material ground before a specific normal grinding force of 90N/mm was reached. The new CBN abrasive outperformed all other conventional CBN abrasives tested producing tool-life values of at least 37% longer than its nearest rival.

INTERTECH Paper - 1162

Dr. Paul Balog

Element Six Ltd. Isle of Man

Ballasalla, Isle of Man - British Isles

TITLE: LARGE SINGLE CRYSTAL HPHT IIA DIAMOND FOR HIGH QUALITY X-RAY OPTICAL PLATES AT 3RD AND 4TH GENERATION LIGHT SOURCES

ABSTRACT: High quality X-ray optics is an essential ingredient for experimental work at large synchrotrons, such as APS Argonne, ESRF Grenoble or SPring8 Japan. Large optical plates for synchrotron applications were manufactured in all three major crystallographic orientations ($\{100\}$, $\{110\}$ and $\{111\}$). A temperature gradient technique employed in large volume High Pressure High Temperature (HPHT) synthesis was used for growing large single crystal (LSC) type IIA diamonds on diamond seeds. Large IIA stones of up to 9.5 ct were obtained. The plates obtained were analysed using Metripol, AFM and surface topography mapping, and tested at the ESRF using white beam X-ray diffraction topography. Reported here are some of the large high quality plates having regions characterized by the absence of stacking faults and dislocations, or with a very low dislocation density.

INTERTECH Paper - 1163

LF van Staden, Composite Diamond Manufacturing Plant

Element Six (Production) (Pty) Ltd. - South Africa

TITLE: SCD - A RANGE OF 3D POLYCRYSTALLINE DIAMOND COMPOSITES

ABSTRACT: The exceptional hardness, stiffness and thermal conductivity of traditional high temperature high pressure (HPHT) polycrystalline diamond (PCD) has allowed it to gain a significant portion of the high value cutting tool and Oil & Gas drilling markets. The HPHT process route imposes significant constraints on both the cost structure and formats of PCD parts manufactured. These constraints have limited the adoption of PCD materials, by industries such as mining and wear parts. These industries present unique and diverse technical and economic challenges, for traditional PCD materials, as they often require larger and more complex formats than those currently offered by traditional HPHT PCD processes. ScD presents unique technical and commercial options and can be viewed as complimentary to the existing portfolio of superhard materials offered by Element Six. Silicon cemented diamond (ScD) is a new type of composite material prepared by means of an infiltration sintering process, carried out under ambient pressure conditions. The composites have a unique combination of properties that can be controlled on a microstructural level, to allow the optimisation of those material characteristics essential to the target application. ScD displays exceptional wear and chemical resistance, together with high elastic stiffness, high thermal conductivity and stability, low density and thermal expansion. These properties, coupled with the ability to produce complex and cost effective 3D shapes, present material selection and new design options, across a diverse range of industries, with a versatile and cost effective super hard material option. Manufacturers of wear parts, i.e. nozzles, guide pads, bearings, seals, construction and mining tools, are working closely with Element Six to evaluate these materials, across a variety of applications, and where appropriate, create unique performance focused products. The following paper will introduce the range of ScD grades and outline the properties, fabrication, processing, behavior and formats available, from this unique superhard composite material, offered by Element Six.

INTERTECH Paper - 1164

Dr. Bert Willems

Hoge Raad voor Diamant (HRD) Antwerp - Belgium

TITLE: STATE OF THE ART CVD SYNTHETIC DIAMOND: A DRIVING FORCE FOR INNOVATIVE CHARACTERIZATION METHODS IN GEM LABS

ABSTRACT: Gem-quality synthetic diamonds produced by chemical vapour deposition (CVD) and their commercialization in the jewelry trade were announced at the beginning of the 21st century. Since then, a real commercial breakthrough has not been observed, as only very limited numbers of gemstones appeared on the market. Significant developments in 4 key areas (size, purity, surface quality and crystal perfection) have unleashed not only a huge engineering potential in technological and industrial applications of single crystal (SC) CVD diamond, but could really offer a window for gem-quality synthetic diamond [1-5]. A recent report describes a near-colourless polished CVD-grown gem diamond larger than 1 ct, that was submitted for grading [6]. It is clear that CVD synthetic diamonds of increasingly better size and colour are being produced. HRD Antwerp is continuously monitoring developments in CVD synthetic diamond and has gained access to the most recent generation of CVD synthetic diamonds. HRD Antwerp has developed a close collaboration with the VD-producing research laboratory LSPM-CNRS (formerly known as LIMHP-CNRS) in Paris (France). LSPM-CNRS develops high-purity, unintentionally doped single crystal CVD synthetic diamond layers for high-power electronic devices. In this way HRD Research collected and examined the latest generation SC CVD plates with varying (nitrogen) impurity levels and growth histories. The samples were analysed using standard gemmological and more advanced luminescence imaging and spectroscopic techniques: the D-Scope gemmological microscope, DiamondView™ imaging, IR and UV-Visible absorption, photoluminescence (PL) and cathodoluminescence spectroscopy. Luminescence spectroscopy and imaging are important techniques for characterizing optical defects in diamond [7]. Line and depth PL profiles were recorded to produce two-dimensional and three-dimensional tomographic images. Combining advanced spectroscopy and imaging techniques in an innovative manner allows gem labs to acquire in-depth gemological, structural and chemical information about the origin and growth history of diamonds which is crucial in the detection and identification of natural and synthetic diamonds. The key message is that fundamental research and innovation are vital in order to improve the detection methods and techniques for synthetic diamonds, reassuring the consumer confidence in the gem diamond trade. References [1] F. Silva et al., DRM 18, pp. 683-697 (2009). [2] R.S. Balmer et al. , Journal of Physics: Condensed Matter 21 364221 (2009) [3] I. Friel et al., DRM, 18, pp. 808-815 (2009). [4] O. Brinza et al., Phys. Stat. Sol. (a) 205, No.9, pp. 2114-2120 (2008). [5] O. De Gryse et al., Antwerp Facets N°2 – Edition 22, pp. 14-15 (2005). [6] W. Wang et al., G&G eBrief, Vol. 1, No. 8 (2010). [7] A.T. Collins , DRM, Volume 1, pp. 457-469 (1992).

INTERTECH Paper - 1165

James McArdle, Lead Product Development Specialist

3M Abrasive Systems Division - USA

TITLE: THE DESIGN AND PERFORMANCE OF TRIZACT(TM) DIAMOND HX ABRASIVES FOR GRINDING AND POLISHING SINGLE-PHASE AND COMPOSITE CERAMIC SUBSTRATES

ABSTRACT: A physics-based model will show the interaction of a composite diamond abrasive article with a transparent, polycrystalline ceramic material. Good correlation between measured and predicted surface quality resulted. Further development and demonstration of Trizact(tm) abrasive capabilities on non-precision ceramic surfaces is presented. High-quality aesthetic results are shown for inorganic flooring materials, including terrazzo, marble, and concrete.

INTERTECH Paper - 1166

Jeff Lantrip, Assembly Technologies - Drilling Process Development

The Boeing Company - USA

TITLE: REQUIREMENTS FOR CUTTING TOOL MATERIALS FOR THE AIRFRAME INDUSTRY

ABSTRACT: The airframe industry has been undergoing a major change with the increased use of composites in structural applications. This drives the increased use of polycrystalline diamond, CVD diamond coating, and other superhard cutting tool products. However, along with the increased use of composites, there is also an increased use of titanium, and the need to drill holes in stacks containing both materials. This is a very challenging application that requires a cutting tool material that is both very hard and tough. This presentation will outline the requirements for new cutting tool materials for the airframe industry.