Developments in Chemical Vapor Deposition Diamond Experience Using Hot Filament CVD Reactors to Grow Diamond for an Expanding Set of Applications Calendar of Events Cubic Boron Nitride (cBN) Coated Cutting Tools for Advanced Machining
The largest manufacturer of synthetic diamond in China and one of the largest manufacturers of industrial diamond in the world.

The Company Features:

**TREMENDOUS CAPACITY**
- Production facility with 2.4 Million Square meters (26 million square feet) of factory space
- Annual output of high-grade synthetic diamond and Cubic Boron Nitride (CBN) can be up to 2 billion carats
- More than 2500 highly skilled employees

**STATE OF THE ART RESEARCH & DEVELOPMENT CENTER**
- Providing High Quality, Innovation and New Technology

**AN INTERNATIONAL SALES NETWORK**
- Guarantees outstanding customer service and support at competitive prices

**ADVANCED TESTING EQUIPMENT TO CONTROL QUALITY AND CONSISTENCY**
- Superior crystal shape, diaphaneity, compact strength and thermal stability

**COMMITMENT TO THE ENVIRONMENT**
- Recycling up to 95% of production materials
- Waste water recycled 100%

**AWARD WINNING OPERATIONS**
- ISO 9001:2000
- China Top Brand
- High-Tech Enterprise Certification
  - China Brand Award For International Market Innovation
  - Certificate Of Conformity Of Quality System

Contact Us Today And Join The Growing International List Of Satisfied Nanyang Zhongnan Diamond Customers...

US OFFICE
American Zhong Nan Inc.
17890 Castleton Street, Suite# 107
City of Industry, CA 91748 USA
Telephone: 626-839-2886
Fax: 626-839-0887
Email: luenyan@hotmail.com
Website: www.diamond-zn.com

CHINA HEADQUARTERS
Nanyang Zhongnan Diamond Co., Ltd.
P.O. Box 101
Fangcheng, Henan China 473264
Telephone: +86-377-67319259, 67319599
Fax: +86-377-67319212, 67318220
Website: www.diamond-zn.com
feature articles

8 Developments in Chemical Vapor Deposition Diamond

14 Experience Using Hot Filament CVD Reactors to Grow Diamond for an Expanding Set of Applications

20 Calendar of Events

23 Cubic Boron Nitride (cBN) Coated Cutting Tools for Advanced Machining

FINER POINTS is the oldest publication devoted exclusively to the understanding, selection and application of diamond, cubic boron nitride and related materials. It is edited for recipients who are involved in some way with these “superabrasives”, either as providers of the materials, producers of products containing the materials or users of these products (e.g., grinding wheels, dressing tools, drill bits, saw blades, sawing wires, cutting tools, polishing compounds, CVD film products, etc.).

COVER PHOTO
Photo of Diamond Reactor Filaments and Coated Materials courtesy of sp3 Diamond Technologies.
In hard numbers, current global recession is measured as 40% decrease of global economy and fifty million lost jobs. So far, twelve trillion dollars have been spent to boost economic recovery. The good news is that the global recession is coming to an end and the recovery might prove a little stronger than previously predicted. We are now wondering how the global economy will recover and also how the world will look after this recession. The consensus seems to be that the current global crisis will produce significant changes to the consumption model and to our way of life. Welcome to the era that will, according to pundits, prove a challenging and lean one. One that will test us on many fronts – financially, socially, economically.... As we know, all lives on Earth depend on the transfers of energy and matter/mass. According to Einstein’s theory of relativity mass and energy are inter-convertible: E = mc^2. Also, the principle of matter/mass conservation states that in a closed system the total amount of mass/matter remains constant over time, regardless of the processes acting inside it. Consequently, matter cannot be created/destroyed; it may be transformed into different states/phases (solid, liquid, gas, plasma, “condensates”). Therefore, the total number of atoms in the Earth is constant (has not changed since its birth), and is estimated to be 10^49 – 10^50. In other words, with the exception of sunlight, the amount of energy-matter on Earth is finite. Many economists believe strongly that the road map to recovery is based on consumption. However, there is growing concern that, as long as the goal of expanding consumption is considered legitimate, we are in danger of repeating past mistakes, as well as, overshooting planetary limits. Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This means that to achieve an acceptable quality of life now and for future generations, the production and consumption of goods and services and their impact on environment must not exceed the carrying capacity of the environment. Climate change, peak oil and all the other unfolding crises associated with pollution and resource depletion are all symptoms of one problem: over consumption and overproduction. If we want to resolve any of the problems arising because we are depleting Earth resources, we have to acknowledge our changed circumstances and set the goal of sustainability as the basic principle for decision making. If we are heading into new times, the real sustaining change will have to be driven by “smart consumption”, which encourages greater product and service effectiveness, efficiency (in terms of resource utilization, etc) and longevity.
The full line industrial diamond supplier… ready to serve your every need.
SUPERABRASIVES MAKE IT LEAN AND TURN IT GREEN

Industry as a whole constantly reacts to current business initiatives or what those of us jokingly refer to as the Flavor-of-the-Month! They have ranged from industry wide programs like Six Sigma, Electronic Commerce, Company Wellness and Self-directed Workforce to company "inhouse" projects like Best Buy, Quality First, Employee Recognition Awards and various Diversity related programs and themes. Most of these programs or tactics have been very worthwhile and delivered tremendous results when taken to heart and followed as intended. While every new idea has its naysayers, the fact is every good idea has its merits and those who embrace the positive will always find positive results. The key to success is to properly apply and execute depending on the psyche and attitude of the workforce and the commitment of management to the program. Two current initiatives relate to developing business plans for lean and green manufacturing. The concept and approach of "lean" is that everything used in production or manufacturing should be strictly applied for the value of the final product ... everything else is wasteful and should be eliminated. A major approach to lean manufacturing puts the focus upon improving the flow of work, which exposes quality problems that already existed, and thus waste reduction is a naturally occurring result. Simply put we are looking for more value with less work. Isn’t the credo of superabrasives more value with less work? This should be an easy sell to manufacturing.

The other main initiative facing all global manufacturers is the push to go green. Whether we like it or not, governments are demanding more environmentally friendly production operations. Companies now must be energy conscious while eliminating waste and harmful emissions.

Manufacturing giants are leading the way in selling and advertising they are green because they feel with more regulations and stricter standards, they can hold a superior advantage over companies that are slow to react. Green is here and only by embracing the idea and getting in line with controls can companies hope to survive. Governments will demand more limits and enforce compliance. Furthermore, consumers are taking a hard look at suppliers to make sure they are doing everything possible to adhere to the green philosophy. Some have even issued policies limiting business only with proven green companies. Everyone is energy conscious and people are looking at ways to reduce the use of energy and wisely use the energy in their operations. Now when we go into office buildings we see the lights out in rooms unoccupied and we get a sense that everyone is taking green to heart in business and their personal actions. Here again, superabrasives are a perfect fit. If industry wants to reduce waste, eliminate hazardous materials this is the obvious choice.

Going green and getting lean are driving forces for industry today and a perfect fit for the increased application of superabrasives. The writing is on the wall, we just have to help everyone read the words and take them to heart.

All Diamond Tools Are The Same...

Fact is that diamond and CBN grinding wheels, dressers, and cutting tools are as different as the companies that supply them. That’s why you’ll find the CITCO name on the wheels and tools that handle the critical jobs in automotive, aerospace, and general manufacturing. Hardened steel, ceramics, laminates, superalloys, composites, reinforced resins, abrasive materials, you name it and CITCO wheels and tools will tame it.

CITCO has more than 60 years of experience delivering diamond and CBN solutions for industry’s toughest problems. Give us a call, and we’ll show you the CITCO difference.

CITCO
Operation Of Landis Gardner
357 Washington St.
Chardon, OH 44024
www.landisgardner.com
1-800-242-7366
Experience Reliability & Exceptional Customer Service

Worldwide Superabrasives, LLC celebrates its fifth year providing the highest quality of industrial diamond and CBN to over 50 customers in 12 countries around the world.

With over 80 years of combined experience in the superabrasives and electroless coating industry, WWSA's superior supply chain management, leading edge plating technologies and an industry leading quality assurance program provides our customers with the most consistent series of industrial diamond and cubic boron nitride grinding products in today's market.

3355 SW 13th Avenue Fort Lauderdale, FL 33315
Phone: (888) 410-1631 Fax: (888) 410-1630 Web: www.worldwidesa.com
DEVELOPMENTS in Chemical Vapor Deposition Diamond

DR. ROBERT LINARES, PATRICK DOERING, BRYANT LINARES – Apollo Diamond

I. OVERVIEW

For centuries, diamond's superlative properties have earned it a reputation as the 'dream' material for mankind in its search to create advanced applications. Until recently, this dream has been realized only in the use of diamond for gemstones and abrasive applications where several tons of diamonds are now used on an annual basis.

The vision of having large, high quality diamond as part of a broad engineering tool-kit for many diverse high tech industries is now becoming a reality however with the advent of early stage commercial availability of single crystal and poly crystalline CVD diamond.

Recent developments in the crystal growth of high quality single crystal diamond via the Chemical Vapor Deposition (CVD) process has allowed device scientists and engineers from many disciplines to think beyond the limitations of HPHT and natural diamond and envision how engineered, pure diamond may be used in advanced applications ranging from quantum computing, to power generation and molecular imaging, and possibly even diamond nano-bots.

II. CVD: A New Growth Phase of Diamond Market Growth

CVD diamonds represent the third and perhaps highest growth phase of the global diamond business. The first phase occurred early in the last century and was driven by mining technology and the consolidation of the diamond mines by Cecil Rhodes. Upon this structural consolidation, diamonds became a true global business with product standards and markets becoming defined. The 1950's saw the global diamond business expand in its second phase through the advent of High Pressure/High Temperature (HPHT) diamond crystal growth technology. Because of its consistency and reproducibility relative to nature sources, HPHT diamond growth technology propelled diamond to the forefront of many industries. HPHT grown diamond crystals are now a cornerstone of the world's industrial base, and the foundation of a global industrial diamond business with multiple billions of carats being produced annually.

CVD diamond represents the beginning of the third phase (and most recent) of the diamond growth path. While early experiments in CVD diamond began in the 1970's, it has only been until recently that pilot quantities and sizes of this extraordinary material have become commercially available. While in its early stages, this phase of the diamond business promises to be the most prolific in its potential and longest lasting, bringing diamond to a ubiquity and impact similar to other fundamental industrial technology materials such as silicon, steel and concrete. The diamond market will grow exponentially from where it is now (albeit in tangential ways) with the new phase of the diamond business growing for the next 50 to 100 years and resulting in diamond as a material used in all parts of our society.

CVD stands for Chemical Vapor Deposition, and it refers to a way of growing diamonds from a gas phase in which large areas of diamond can be deposited and crystals grown. The other interesting features of CVD diamond are its properties, which can be adjusted to either include or exclude impurities, and additionally change its crystal structure. Single crystal structure and poly crystalline structure of various sizes can now be grown.
The tailoring of CVD diamond properties and the large sizes that can now be grown are key benefits of the CVD growth technology. These process features make diamond very attractive to a wide variety of other industrial fields that previously could not use diamond because of limitations in crystal size, perfection and consistency.

The field of CVD diamond crystal growth is still young, but it is beginning to move into the commercial phase, and advances into manufacturing are occurring at a rapid pace. Demand in traditional markets such as cutting tools and gemstones currently outstrip the capacity of global CVD producers to provide diamond material in sufficient quantities and the prospects for explosive growth remain strong. Some of the most intriguing commercial markets exist in areas of high technology that were outside of the traditional diamond markets. Recent breakthroughs in applications research project CVD diamond having a growth path similar to that of Silicon, finding its way into the next generation of technology applications ranging from quantum computers to solar panels. Diamond will become ubiquitous in our society over the next 25 years.

III. CVD Process and Material

One specific area of the CVD process focuses on growth of single crystal diamonds, the same type of diamond that is found in gemstones mined from the earth. Single crystal diamond grown through this process has exceptional qualities for use in advanced electronics and optics applications. Nonetheless, the superior characteristics of single crystal diamond can only be applied to these applications if the diamond material is consistent in its size and crystal properties. These requirements make the CVD diamond growth process ideal for these high tech applications.

EQUIPMENT AND PROCESS

The diamond crystal growth equipment used in the CVD process is both expensive and highly specialized. A standard setup consists of a vacuum chamber, a holder for the diamond, and a heating source to superheat the chamber’s atmosphere. In a lab or manufacturing environment, the crystal growth chamber is usually accompanied by some form of laser cutting and diamond polishing equipment to fabricate the diamond in pre-production and post production process. This same set of diamond crystal growth resources can be used to grow either poly crystalline diamond (nano and ultra-nano scale), or single crystal diamond.

When the CVD process is applied to single crystal diamond growth the input materials are a hydrocarbon (carbon and hydrogen) gas, and a seed of diamond. The seed is a thin sliver of single crystal diamond that acts as an atomic template for the ensuing crystal growth. This is necessary as the starting point for all single crystal diamond at this point in time. Generally, you must start with a piece of diamond seed and then add to it.

As gas is added to the chamber and heated to temperatures approximating that of the outer areas of the sun, the hydrocarbon gas begins to breakdown and the carbon atoms attach themselves to the seed of diamond in the vacuum. By managing the growth process the shape of the diamond and its crystal features can be managed to a certain degree. This is important as you can steer the CVD process to impart certain engineered properties to the ensuing diamond for application tailoring. To further tailor the diamond properties, impurities can be

Note Growth Steps on CVD Material. Shape and size of steps controlled by Chemistry, Substrate Temperature, and Presence of Impurities.
WORLDWIDE SUPERABRASIVES, LLC IS PLEASED TO ANNOUNCE A NEW WWSA PRODUCT CATALOG AND THE LAUNCH OF ITS NEW AND IMPROVED WEBSITE
WWW.WORLDWIDESA.COM  Fort Lauderdale, FL – The new WWSA catalog features an expanded product line, greater application details for end users and a brief overview of manufacturing processes and quality assurance program. The updated website offers intuitive navigation with easy to find product information, an improved graphical user interface that is visually pleasing and an interactive WWSA product catalog. Worldwide Superabrasives, LLC celebrates its fifth year providing the highest quality of industrial diamond and CBN to over 50 customers in 12 countries around the world. With over 80 years of combined experience in the superabrasives and electro-less coating industry, WWSA is committed to providing the highest quality superabrasive products while offering our valued customers exceptional customer service.

VOLLMER GROUP PROUDLY CELEBRATES 100 YEARS OF SUCCESS – Vollmer began in 1909 in a small workshop in Ebingen. The company is recognized as an industry leader in the sharpening, production and maintenance of saw blades and diamond tooling. Today the Vollmer group employs 700 people working out of 12 subsidiaries in Europe, the Americas and Asia. The change from a machine tool manufacturer into a future oriented technology and service provider reached its latest milestone with the opening of the new Technology and Training Center (TTC) in Biberach Germany. The building offers over 3000 square meters of classroom, meeting rooms and machine demonstration areas. For further information visit www.volmer-us.com

ENGIS CORPORATION STRENGTHENS DIAMOND TOOL TEAM WITH NEW BUSINESS UNIT MANAGER – Superabrasives specialist, Illinois-based, Engis Corporation, has announced the appointment of Richard Marshall to the newly created post of Business Unit Manager of its Diamond Tool Product Line. Richard brings with him over 25 years of experience in the industrial diamond grinding industry, and has held positions including product development, sales and marketing, engineering, customer service and manufacture. In his new role he will be reporting to Steve Griffin, Engis Corporation President, and will have responsibility for the entire operation of Engis’ Electrogrip product line, including the customer-led Electrogrip Cell, Inspection, Machining Shop and Plating Shop, as well as the Bore Finishing Tool manufacturing and lapping plate manufacturing. Richard’s focus will be to further improve Engis’ support services, working closely with the John Smallshaw and the sales department to increase the market penetration of these products. Welcoming Richard to the company, Steve Griffin explained; “As we look forward to the economic recovery it is crucial that we have the resources in place to provide our customers with the best possible service - Richard’s extensive knowledge of the industry will help us achieve this objective.” For further information visit www.engis.com

TYROLIT ACQUIRES AMERICAN ABRASIVES MANUFACTURER RADIAC ABRASIVES – Radiac is the second largest manufacturer of bonded conventional and superabrasive grinding wheels in North America. Radiac operates four manufacturing facilities in the USA and Mexico. Headquartered in Salem, Illinois, the company consists of production centers, sales and representative offices at various locations in the USA, Canada, Mexico, Latin America, Ireland, and Poland. Radiac® will be retained as an independent brand and ideally complements Tyrolit’s portfolio in the US. Based on Tyrolit’s long-standing and sound technical expertise and wide range of products, they expect to leverage significant distribution synergies for the expansion of Radiac’s range. The new synergies in the areas of production, purchasing, sales, and customer service will open up new opportunities in the American market. Because of the considerable market size, the demand for abrasives in North America accounts for almost 25% of the global demand for abrasives. For many years, our industry has witnessed a constant process of consolidation in the abrasive market. The current economic crisis further accelerates this development. Tyrolit has accepted these challenges by actively pursuing this acquisition. For More Information visit: www.tyrolit.com

ILJIN DIAMOND NAMES KYOOSOOL CHOI AS PRESIDENT – ILJIN Diamond Co, Ltd, a world leading manufacturer in Superabrasives, announced that Yoonyoung Lee, the CEO of ILJIN Diamond Co. Ltd left his position on September 4th 2009 and named Kyoosool Choi for his successor as President, effective September 7, 2009. Yoonyoung Lee has led ILJIN Diamond in establishing strong partnerships with customers and creating new momentum for long-term growth of the company during his 3 years of service. He will remain in the ILJIN Group in ILJIN Holdings Co. Ltd. Kyoosool Choi has been with the ILJIN Group for 19 years and has spent most of his career in ILJIN Diamond Co Ltd. His previous position was VP of marketing & sales. Kyoosool Choi brings his outstanding leadership to meet the challenges of the future and generate great value to the company. For more information contact ILJIN Diamond Co. Ltd www.iljindiamond.com
selectively and controllably added to the growing diamond by adding gases that contain elements such as boron, nitrogen or phosphorous.

**FABRICATIONS**

CVD diamonds can be used to grow thin layers or to create bulk chunks depending on the goals of the crystal growth process. Layers can alternate between intrinsic (pure) diamond layers and layers of doped diamond material, creating features inside the resulting diamond that are unique to the diamond grower’s designs. These features and layers may be used to selectivity create or relieve strain in the diamond or to create patterns to enable special functions (such as channels or reservoirs).

The resulting diamond can be further fabricated post growth via traditional semiconductor process technologies. These processes include more traditional steps such as laser cutting and polishing but also include advanced fabrication such as etching, implanting, and photolithography. While early in their development, many of the fabrication technologies available to the semiconductor industry are also directly applicable for the processing of diamond.

**CVD DIAMOND CRYSTALS: MATERIAL CHARACTERISTICS**

Because of the ability to engineer and craft diamond growth during the CVD process, a wide variety of diamond materials is emerging that will be relevant to a wide variety of applications.

One way to view the flexibility of the CVD process is to consider some of the process parameters and material properties that can be independently controlled during the crystal growth process. There are three important process control knobs that the diamond grower has at his/her disposal to prepare the specific type of CVD diamond structure required to meet the needs of the end application. Within the parameter limits of each control knob there is an increasing amount of tuning and precision that is currently being built into the process.

The very concept of how to think about the type of diamonds that the CVD technology enables is in the early stage of developing. This is important in the areas of applications development where business models were built around the scarcity of natural diamonds or the physical limits of size and purity for HPHT diamonds. The new vision is for diamond wafers up to 100 mm wide over the next decade, diamond with controlled and consistent properties, and diamond structures, which are tailored to fully exploit the potential that diamond has for existing and new applications. CVD diamond growth process is the only path for diamonds of consistently large size and low impurities.

Through advances in CVD growth, diamonds are in the process of becoming large and more ubiquitous, in qualities and characteristics that have just never been available before. Diamonds will in fact change the world and appear in many of the high use applications we take for granted like computers, communications and medical devices. This is the materials inevitable path.

Full utilization will take some time as the CVD process moves into manufacturing volumes but the early results from applications developers are staggering. We are not saying that the world is going to be awash with tons of man-made diamond gemstones either. It is very difficult to grow single crystal diamond thick enough for gemstones. While the world will utilize tens of millions...
of crystals of single crystal diamond for high tech applications, they will mainly be in the form of thin wafers (one quarter to one half millimeter thick) containing internal layers and structures to tailor the properties, and processed through standard semiconductor fabrication processes (such as etching, photolithographic patterning and metallization).

**IV. High Growth Applications and Markets**

Because of its high utility and projected availability, single crystal CVD diamond will be used in most major application categories. We see most technology vertical market categories consuming large amounts of diamond over the next five to ten years.

Most of these markets have multiple billion-dollar sub-components where diamond will yield a significant cost-benefit impact. Some of the areas where we see CVD diamond integration are as follows:

As an example, diamond happens to be the ultimate semiconductor material due to its combination of electrical, thermal, and optical properties. Its extreme properties give it unsurpassed utility and performance in thermal management, electrical resistivity, hardness and when doped with boron or phosphorous, electrical conductivity. Until the past few years, tapping these capabilities was thought to be impossible because of the lack of engineered, high quality diamond.

Advances in a number of CVD diamond crystal growth programs now make it possible to drive this advanced material into rich opportunity spaces where there is a large need for technical and efficiency improvements.

The global economy needs more diamonds than the earth can easily provide and with sizes and purities that are beyond the capabilities of HPHT grown diamond.

Diamond technologies will be pulled by the demands of high tech applications to operate faster, more reliably and in extreme environments. These requirements will drive the diamond crystal growth technology to quickly transcend the manufacturing demands currently required by gemstones, and other traditional markets.

While the industrial support base needs to expand and assimilate CVD diamond and its capabilities, the prospects for extreme growth in this industry are profound. High quality CVD grown diamond material is at the beginning of a fifty to one hundred year growth curve that will impact our society in a ways similar to that of the Silicon ‘revolution’ which began in the 1960’s.

<table>
<thead>
<tr>
<th>DIAMOND PROPERTY</th>
<th>APPLICATION AREAS</th>
<th>FUNCTION</th>
<th>IMPACT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beautiful, relatively scarce, permanent, well-marketed, symbolic significance</td>
<td>Jewelry</td>
<td>Gemstones</td>
<td>- Gem Markets</td>
</tr>
<tr>
<td>Highest Hardness</td>
<td>Tooling</td>
<td>Wear Resistance</td>
<td>- Machine Parts</td>
</tr>
<tr>
<td>Highest Compressive Strength</td>
<td>Machinery</td>
<td>Less Lubrication</td>
<td>- Superabrasives</td>
</tr>
<tr>
<td>Low Thermal Expansion</td>
<td>Composites</td>
<td>Structural Strength</td>
<td>- Cutting Tools, Drills</td>
</tr>
<tr>
<td>Highest Tensile Strength</td>
<td></td>
<td></td>
<td>- Prazors, Surgical Tools</td>
</tr>
<tr>
<td>High Thermal Conductivity</td>
<td>Electronic</td>
<td>Heat Sinks</td>
<td>- Dielectric Windows</td>
</tr>
<tr>
<td>Excellent Electrical Insulator</td>
<td>Device packaging</td>
<td>Heat Spreaders</td>
<td>- High Speed CPUs</td>
</tr>
<tr>
<td>Excellent Semiconducting Properties, Wide Band Gap</td>
<td>Electronics</td>
<td>Power Electronics, Wireless Devices</td>
<td>- Schottky Diodes</td>
</tr>
<tr>
<td>Negative Electron Affinity</td>
<td>Computing</td>
<td>Communications, Semiconductors</td>
<td>- High-Ist FETs, SAW Devices</td>
</tr>
<tr>
<td>(excellent electron emitter)</td>
<td></td>
<td>Ultra-fast switches, Ultra-fast switches</td>
<td>- Utility Lines</td>
</tr>
<tr>
<td>Excellent Optical Transparency (UV - IR)</td>
<td>Photonic</td>
<td>Optics, Displays, cold cathode devices</td>
<td>- Radiation Detectors</td>
</tr>
<tr>
<td>Biocompatible, Chemically Inert</td>
<td>Biotechnology</td>
<td>Sensors</td>
<td>- Aerospace, Defense</td>
</tr>
<tr>
<td></td>
<td>Electrochemistry</td>
<td>Electrodes</td>
<td>- Flat Panel Displays</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- LEDS, TVs</td>
</tr>
</tbody>
</table>
LACH DIAMOND, INC. ANNOUNCES ITS NEWLY DESIGNED DISPOSABLE ROUTER BITS.

These new tools feature a diamond plunge point, instead of carbide, and have two effective teeth at the tip. This assures significant tool life for plunging and routing demands. Though these Router bits are considered disposable, they can most often be sharpened one to two times, depending on condition. Router bits are available to ship from stock. For more information contact: www.lachdiamond.com

NIABRAZE CORPORATION INTRODUCES THEIR SECURED DIAMOND SAW (SDS) WIRE

For wafering and cutting hard, brittle materials without the use of slurries. SDS wire is manufactured using an electrolytic plating process to secure fine micron diamond particles to the surface of high tensile strength steel wire with uniform concentricity and diamond exposure. SDS wire allows for environmentally friendly cutting because the only cutting solution needed is water along with a biodegradable machining surfactant. Most materials can be processed at 2-3 times the rate of slurry sawing and SDS wire is compatible with most single and multi-wire saws currently being used today. Thomas Bluemle, Vice President of Niabraze Corporation says “Niabraze is very encouraged by the opportunities their SDS wire presents because of the demand for thin kerf cutting of expensive hard to cut materials. Our diamond wire is a comparable alternative to current fixed grain diamond wire in the market but also as a cost effective and clean conversion for operations currently slurry sawing.” Niabraze encourages those interested to visit their website, www.niabraze.com

SCHUNK IS EXTENDING ITS TOOLHOLDER PRODUCT RANGE WITH THE NEW TOOLHOLDER FOR HEAVY-DUTY METAL CUTTING

The new SINON-R is especially well suited for heavy-duty metal cutting and rough milling. The universal toolholder is based on the expansion technology system with a solid body as a pressure medium and is clamped in no time using a simple actuation key. This saves the user a lot of set-up time and considerably reduces unproductive machine downtimes. The excellent interaction of high radial rigidity and very good dampening characteristics is a special highlight that reduces machining noises and increases the smooth running of the tool. The result: a high service life of the tool and unsurpassed surface quality of the workpiece. Unwanted chatter marks that frequently appear with conventional toolholder systems and expensive reworking are a thing of the past. For further information: www.schunk.com

WALL COLMONOY CORPORATION INTRODUCES COLMONOY 88 FOR WASTE TO ENERGY PLANTS

Over three years ago, a large waste-to-energy plant performed the first large-scale test of a Colmonoy spray-and-fuse alloy. The tubes were coated 25 feet in length and 2.5” in diameter. Tube-metal temperatures approached 900 F, and the boiler ran 24/7. The tubes are vital components of a superheater in one of the boilers, and a way of protecting the tubes to extend their life from, at best, Colmonoy 88 extends boiler tube life, especially in the secondary superheater section of a boiler where the most severe environment exists for mass burn and refuse derived fuel boilers. The waste to energy plant is pleased with the test results and plans to test Colmonoy 88 in two other plants. For further information about this application, please contact abreer@wallcolmonoy.com

LUOYANG MEIK DIAMOND CO., LTD is manufacturer of high quality CVD diamond that is pure diamond with polycrystalline structure and also has excellent transmission, high thermal conductivity and especially high wear resistance. It is mainly used for:

★ dressing tools
★ cutting tools
★ wear parts

Available in various shapes and sizes for many applications

For further information, please contact at:
LUOYANG MEIK DIAMOND Co., Ltd
Add: No.22,Binhe Road,High-Tech Development Zoné, Luoyang 471003,China
Tel: +86-379-64320193  Fax: +86-379-64326002
E-Mail: info@cvddiamond.com.cn  Web: www.cvddiamond.com.cn
Experience Using Hot Filament CVD Reactors to Grow Diamond for an Expanding Set of Applications

DWAIN A. AIDALA, President sp3 Diamond Technologies, Inc.
Santa Clara, CA, USA • www.sp3diamondtech.com

Background
Fifteen years ago work was just beginning to develop chemical vapor deposition (CVD) equipment, processes and products to exploit the unique properties of diamond. One of the main challenges was to select a technical path that would provide for reliable, cost effective manufacturing on a production scale, day after day. After much analysis, hot filament CVD was determined to offer the best route to cost-effective large area deposition in two and three dimensions. As tremendous experience in DC glow discharge, microwave, hot filament and DC torch-grown diamond has shown, the selection of hot filament as the reactor technology of choice for diamond deposition has proved to be an excellent decision.

CVD diamond has a broad range of applications, from diamond cutting tools (Figure 1), to wear scales, to providing thermal management for electronic applications through products such as diamond-on-silicon.

Equipment, Process and Film Growth Using Hot Filament Reactors

Cutting Tools
A hot filament system deposits over an area approximately 350 mm by 375 mm. It employs fine wire filaments (0.122 mm in dia.) in a cold wall aluminum chamber; typical total system input power is between 22 kW and 30 kW. The system’s filaments are horizontal, and can be arranged in a two-dimensional or three-dimensional array. A sophisticated process controller provides for complex deposition recipes with up to 58 discrete steps. This high degree of program control is critical for the proper management of orderly startup, nucleation, growth, and shut down and, most important, safety. This system has grown a wide range of films from nanocrystalline smooth films as thin as 1000 angstroms to more granular films as thick as 1000 microns. Typically, films used in coating cemented carbide cutting tools are in the range of 10 to 40 microns thick. Diamond and cemented carbides have quite different coefficients of thermal expansion. As the films get thicker, the adhesion bond between the diamond film and the substrate is put under increasing stress as the substrate returns to room temperature from the normal deposition temperature of 800 to 900°C. The present technology to promote the adhesion of diamond on cemented carbides will tolerate films up to about 50 microns thick for cutting tool applications. Both coarse and fine grain films are used in cutting tools. The coarse films are best suited for roughing applications. Fine grain films are often used when sharper edges are required or chip evacuation is an issue, as with endmills and drills. Grain size can also affect surface finish of the workpiece.
It is quite easy to vary the grain size as well as other properties of the grown films with the programmable process controller employed by the hot filament system.

**Electronic Applications**

Silicon wafers have also been successfully coated using hot filament technology. Wafers as small as 50 mm up to as large as 300 mm have been coated for a wide variety of uses, as well as serving as prototypes for electronic applications. Typical films are 1 to 3 microns thick and are grown on silicon wafers when aiming to exploit diamond’s unique electronic properties. Adherent diamond films have been grown on silicon wafers up to 300 mm in diameter. The properties of these films are typically uniform to +/- 10%, including film thickness over the full diameter. In the nanocrystalline films the typical grain size is 10 to 100 times finer than the fine grain cutting film shown above in Figure 3. Using Raman analysis, these thin films still exhibit the typical diamond 1331 peak. Films can be either undoped or doped with boron for those applications requiring electrical conduction. The Raman signature of a 1-micron film grown on a 200 mm wafer is shown in Figure 4.

**Thermal Management**

Films up to 50 microns thick have been grown on 200 mm wafers in hot filament reactors for experiments in thermal management of integrated circuits. Flatness, fixtureing in the reactor and the thermal performance of the diamond are all considerations. Hot filament reactors have grown 20-micron films on 200 mm, 750-micron thick silicon wafers while maintaining a flatness of 50 microns. These processes have evolved into a structured substrate that consists of device-quality silicon layer on a thermal layer of diamond atop a silicon handle wafer. Dubbed Silicon-on-Diamond (SOD), these substrates provide either a FZ or CZ top silicon layer for devices processes such as GaN on Silicon needing higher thermal conductivity substrates for maximum device performance (Figure 5).

**Other Diamond on Substrate Applications**

**CMP (chemical mechanical planarization)**

CVD diamond has also been used for CMP pad conditioning required for semiconductor manufacturing. A thin layer of CVD diamond was grown on a silicon wafer; diamond grit of a specific size was then arrayed on the wafer and an additional layer of CVD diamond was grown, epitaxially bonding the grit between two layers of CVD diamond. It should be noted that this product could only be produced in a reactor with horizontal filaments. The pad conditioners are supplied in both 50 mm and 100 mm diameters. Some typical pad conditioners are shown in Figure 6.

**Mechanical Applications**

In addition to cutting tools coating cemented carbide, silicon carbide and silicon nitride in a wide variety of shapes when extreme wear resistance is required has also been achieved. These films tend to require smooth surfaces, either as grown or polished after growth. Hot filament technology allows for the uniform growth of these smooth films with surface finishes better than 0.2 micron Ra. Applications are guides, wear surfaces, pivots, and seals. Some typical seals are shown in Figure 7.

**Electrodes**

Many applications in electrochemistry require electrodes to conduct the appropriate electrical power in the reaction. In many instances, electrodes are formed from titanium mesh and then coated with various noble metals. These electrodes come in a wide variety of sizes and shapes with maximum sizes approaching 1m by 1m. Hot filament deposition is clearly superior for this technology because of the ease of scaling to these large areas. Electrodes fabricated from titanium mesh and coated with hot filament CVD diamond have clearly demonstrated longer life over the typical noble metal coatings.
Premium Saw Diamond
There is nothing that ILjin Premium Diamond cannot cut except for the sky and water.

ILJIN Diamond,
the Leading Company of Tool Materials.

**IPD Series** ILJIN PREMIUM DIAMOND Fruit of the-state-of-the art synthesis technology. IPD Series is engineered to have high strength, thermal stability and well-defined cutting edge, which will lead to improved performance even under severe working conditions. Its high strength and micro-fracturing behavior result in lower and more steady power consumption, and initial power level is low due to sharp cutting edge. Strength deterioration is minimized by controlling the defect amount within. This new high-end diamond will enable diamond tool producer to expand the applications.

- Highest Grade Products for Severe Working Conditions & Applications
- Available Mesh Size: 30/40, 40/50

Extremely High Toughness
Excellent Shape & Edge
Micro-Chipping Ability

Creating New Value

ILJIN BD 14F, Dohwa-Dong 50-1, Mapo-Gu, Seoul, 121-716, KOREA Website: www.ijindiamond.com
Tel. +82-2-707-9083 Fax. +82-2-707-9378
IBON is Polycrystalline Cubic Boron Nitride (PCBN) with fine grained and randomly oriented texture developed by ILJIN Diamond’s latest technology. The new IBON products are specially designed for machining ferrous materials – cast irons, hardened steels, powdered metals and heat-resistant superalloys. Available grades: SB100, SB95, SB90, SB80, SB70, SB60, and SB50. Disc Size 57MM Diameter

IPOL stands for ILJIN Polycrystalline Diamond (PCD). IPOL-PCD is characterized by superior hardness, excellent wear resistance, highest thermal conductivity and uniform wear in all directions. It’s designed for machining non-ferrous metals, alloys, tungsten carbides, plastics, wood, ceramics and wear parts. Available grades: CC, CM, CF, CMW, CXL, CXL II, CUF and CXUF-sub micron. Disc Sizes 60MM & 75MM Diameter

CVD is Chemical Vapor Deposition Diamond

“IT’S PURE DIAMOND”

- Harder, more wear-resistant
- High thermal conductivity
- Better chemical and thermal stability
- Lower coefficient of friction

Available in various shapes and sizes for many applications.

FACTORY
614-2 Oryu-ri, Daeso-myun, Eumsung-gun, Chungcheungbuk-do, Korea
http://www.iljindiamond.com

AUTHORIZED DISTRIBUTOR
AMERICAN SUPERABRASIVES CORP.
59 AVENUE AT THE COMMONS, 2nd FLOOR, SHREWSBURY, NJ 07702 • TEL. 732-389-8066 • FAX 732-389-8069
www.diamonds-abrasive.com • Email – njabrasive@aol.com
when used in a wide variety of electrochemical applications. In addition to titanium, silicon substrates are proving to be a cost effective substrate for diamond coated electrodes.

**Processing – Why Hot Filament?**

**Ease of Scaling**

The deposition area of a microwave reactor is, in part, limited by the frequency of the plasma generator. The maximum deposition area in state-of-the-art microwave systems is limited to about 150 mm in diameter. Some DC torches are capable of deposition over areas up to 200 mm. Current hot filament reactor deposits over an area 350 mm by 375 mm, with the potential to deposit over an area 1000 mm by 1000 mm, or to increase from nine 100 mm wafers to thirty-six 100 mm wafers in the same configuration, when the market requires it.

**Lowest Cost Deposition**

Hot filament reactors are reasonably straightforward in their execution. DC power is used, the reactors are simple mechanically, and control is straightforward. Control mainly comprises gas ratios and flow rates, vacuum level, and the amount of DC power in the filaments. Care must be taken to fixture the reactor correctly to insure that substrates run at proper temperatures. Careful fixturing design can usually result in achieving optimum substrate temperatures without the need for substrate heaters or coolers. When looking at the cost of deposition one must consider the capital investment, operating expenses—utilities required such as power and gases—ease of use, and reactor reliability and availability. Capital investment of a hot filament system for a given quantity of diamond grown is about 1/3 to 1/2 that of microwave systems on a cost per carat basis. Experience has clearly shown reactor uptime time over 90 percent and reactor availability (defined as deposition time as a percentage of total time) of over 90 percent. Disposable parts are minimal and the power generating systems are simple DC power supplies. In an ideal design, the filaments can be easily replaced on every cycle, with a set of filaments costing less than $10.00. This approach eliminates the need for a costly and unreliable load locked system. As an additional benefit, this allows for fine-tuning a given recipe to achieve a specific deposition goal.

**Growth Rate**

Hot filament reactors are often perceived to grow diamond at a slow rate. Diamond does grow slowly in any CVD reactor; hot filament reactors typically grow diamond at 0.3 to 2.0 microns per hour, microwave systems from 1.0 to 5.0 microns per hour, and DC torches have demonstrated growth rates exceeding 20 microns per hour. With respect to growth rate, it is important to remember that in a hot filament reactor the diamond is being grown over a large area. The definitive measure of growth is carats per hour for a given capital investment plus the costs of operation such as maintenance and utilities, labor, overhead and power consumption. When measured in these terms, hot filament systems have about twice the efficiency of typical microwave systems or DC torch systems. On cutting tools, typical growth rates are 0.8 to 1.2 microns per hour using both two-dimensional arrays for flat tools and three-dimensional arrays for round tools. A hot filament reactor can coat 250 or more flat tools or up to 150 round tools in a reactor load. These large quantities per run help offset the slower growth rate. The typical approach is to turn the reactors once a day and add reactors incrementally as the business grows. On large surfaces such as a 200 mm wafer, growth rates drop to about 0.4 microns per hour. Currently there is work being done on some enhancements to bring the growth rate to about 1 micron an hour on surfaces greater than 100 mm. Moving to higher temperatures can introduce new manufacturing problems, so CVD diamond technologists are actively working towards lowering substrate deposition temperatures while maintaining present growth rates.
Uniformity

Uniformity is an area where hot filament reactors have clearly demonstrated their superiority over both microwave and DC torch approaches. A typical reactor load in a hot filament system may comprise several hundred cutting inserts, over 100 round tools, multiple 150 mm or a 300 mm silicon wafer. A hot filament reactor has the advantage of uniform temperature across the entire deposition area without rotating the substrate. In contrast, microwave reactors and DC torches create a sphere or plume of energy that is hotter at the center than at the edge. Another phenomenon observed is that substrates in microwave reactors and torch reactors tend to get hot spots on sharp corners of the objects being coated. These high corners create problems in tool clamping, and maintaining a consistent edge radius or hone is nearly impossible. Hot filament reactors have clearly demonstrated uniform temperature across large deposition areas and, equally importantly, uniform coatings across an individual substrate. Figure 8 is a schematic representation of some of the uniformity issues.

Safety

As systems get larger, safety becomes an increasing concern. The typical hot filament system uses 30 kWe of DC power. This is an easy level to manage and control when using DC power. If there were to be a runaway situation the wires will overheat and break, creating an open circuit. On the other hand, microwave systems operating at 30 kWe power levels can be dangerous. If the plasma ball should jump to the walls of the chamber a catastrophic event is the probable outcome. High power microwave systems also have shown evidence of benzene and benzene byproduct formation during the deposition process. Some of these complex hydrocarbon chains have carcinogenic properties. We have seen no evidence of benzene type hydrocarbons in hot filament systems. Hot filament systems also have both hardware and software interlocks to provide maximum protection to both the operator and the system itself. The controller allows for the setting of limits that, when exceeded, will cause the system to shut down and the event will be logged. In addition, the system protects against software failures with hardware interlocks. The cabinet and chamber doors are interlocked to prevent the user and the system cannot be energized if the doors are not fully closed and the system is at the correct operating conditions.

Accurate Temperature Control

Temperature control is critical to consistent and uniform diamond deposition. It is much easier to govern the voltage on a hot wire for temperature control than to try to govern the proximity of a plasma ball to a substrate in the typical microwave system, especially if temperature control over a large area is critical. Substrate temperature control within +/- 5°C is common in hot filament systems. With a hot filament system, it is this accurate control of deposition temperature that provides the ability to coat in both two-dimensional and three-dimensional arrays, as illustrated for inserts and round tools in Figure 3.

Process Control

The combination of a sophisticated control system and a technical approach that lends itself to control has allowed development of a reactor with a great deal of flexibility. The system incorporates a process controller developed specifically for the control of plasma CVD depositions in the electronics industry. It governs pressure, power to the filament wires, vacuum levels, safety interlocks, etc. The controller can store individual recipes that may have up to 58 process steps and may ramp between steps. An example of a smooth fine-grain, graded layer film produced in a hot filament reactor is shown in Figure 9. This is a smooth, contiguous one-micron thick-layered nanograin film deposited using patented Graded Layer technology. Process conditions were varied to generate a film composed of ten 1000-angstrom thick films, each composed of a graded layer structure.
October 12-14, 2009
Powder Metallurgy Congress and Exhibition
The Bella Centre
Copenhagen, Denmark
www.epma.com/pm_2009

October 19-22, 2009
Canadian Manufacturing Technology Show
Direct Energy Centre
Toronto ON CAN
e-mail canadasales@sme.org or call 888-322-7333

October 20-22, 2009
Wichita Industrial Trade Show (WITS)
Century II Convention Center
Wichita, Kansas
www.witshow.org

October 21-22, 2009
Advanced Manufacturing & Technology Show (AMTS)
Dayton Airport Expo Center
www.daytonamts.com

October 21-24, 2009
Stone Expo-Las Vegas
Las Vegas Convention Center
3150 Paradise Road • Las Vegas, NV
In Summary

Hot filament reactors have proven to be efficient and cost-effective diamond deposition systems for an ever widening set of applications. The systems are easy to operate and have proven to be very reliable. Hot filament reactors successfully coat both flat and round cemented carbide cutting tools, silicon carbide seals of various shapes and sizes, and silicon wafers for applications from as small as 50 mm up to a maximum of 300 mm. With respect to manufacturing cost, diamond deposition represents only a secondary portion of the total cost of almost any product. In cutting tools, for example, the diamond deposition cost is less than 30 percent of total product costs. It is important to choose a deposition approach that provides proper uniformity, control, repeatability, and ease of scaling. Deposition over large areas is often more useful than a focus on microns per hour when evaluating overall growth rates. Experience has shown, time and again, that hot filament reactors provide a reliable, safe and cost-effective path to CVD diamond product development and long-term production. There will be a continuing effort to develop, improve and refine the use of hot filament reactors as they represent the best choice for almost all applications of CVD diamond.
There's a wonderful world around us. Full of fascinating places. Interesting people. Amazing cultures. Important challenges. But sadly, our kids are not getting the chance to learn about their world. When surveys show that half of America's youth cannot locate India or Iraq on a map, then we have to wonder what they do know about their world. That's why we created MyWonderfulWorld.org. It's part of a free National Geographic-led campaign to give your kids the power of global knowledge. Go there today and help them succeed tomorrow. Start with our free parent and teacher action kits. And let your kids begin the adventure of a lifetime.

It's a wonderful world. Explore!

Simplify lapping & polishing, with greater precision and consistency.

Lapping and polishing challenges involving electronic crystals, ceramics, metals and advanced material substrates demand a highly precise and consistent process of surface preparation and cleaning. The Saint-Gobain Surface Conditioning Group simplifies things by providing everything your process requires, end to end:

**Substrate Preparation**
- Superabrasive diamond, cBN, B4C powders, slurries & compounds
- Non-superabrasive (alumina, zirconia) powders, slurries & compounds
- Polishing cloths

**Substrate Cleaning**
- Biodegradable lubricants, coolants & cleaning solutions

**Post-Lapping/Polishing Cleaning**
- Wide selection of proven formulas for all materials
- Technical & application expertise & support

Simplify your process with Saint-Gobain. Call us today.
A nano and micro composite coating series based on cubic boron nitride (cBN) particulates and choice of applications specific binders was developed for machining engineering materials. The coating series were produced via two-step sequential processes: electrostatic spray coating (ESC) of nano and micro sized cBN particles (<2 μm) for a conformal porous coating green preform of designed thickness followed by chemical vapor infiltration (CVI) of ceramic binder phase(s) at a temperature of around 1000°C for a dense and well adherent composite coating. This article shares application cases where the new coating was tested for its performance in turning AISI 4340 hardened steels, AISI 4140 pre-hardened steel, and ductile cast iron at representative application conditions, and compared to correspondingly industrial benchmarks. Testing results showed that the new cBN coating outperforms its industrial counterparts, such as polycrystalline cubic nitride (PCBN) brazed inserts, titanium aluminum nitride (TiAIN) deposited by physical vapor deposition (PVD), multilayer coating by chemical vapor deposition (CVD), and aluminum oxide (Al₂O₃) bulk tools, in respective applications.

Cubic Boron Nitride (cBN) Coated Cutting Tools for Advanced Machining

By: Wenping Jiang, Bob Reed, Henry Reneger, Calvin Golorth and Ajay P. Malhe
Duralor LLC, Springdale, Arizona 72764

Introduction

Diamond is the hardest material known and has been used as a cutting tool for long time. However because of its aggressive reaction with iron, it cannot be used for cutting ferrous alloys. Boron nitride based tool, on the other hand, has an outstanding thermal stability and chemical inertness to iron and lists as a second known hardest material. Diamond and boron nitride (BN) based tools complement each other - diamond can cut only non-ferrous materials (volume of 75-80% of the total machining market) and boron nitride can cut all ferrous alloys (volume of 20-25% of the total machining market). Currently, sintered cBN ceramic brazed tools have been used in sawing, cutting and crushing applications whereas thin film cBN is the best candidate for the coating on cutting chip-breaker tool inserts, rotary tools and wear parts. The polycrystalline boron nitride
Fig. 1: Image showing examples of turning inserts coated with the new cBN coating.

Fig. 2: A comparison of tool performance between cBN coated and PCD coated inserts.

Fig. 3: Typical flank wear on cBN-coated insert and PCD tipped insert.

Fig. 4: Graph showing the tool performance of cBN coated insert and PVD TiAlN coated insert in continuous turning of AISI 4340 hardened steel.

Fig. 5: SEM images showing the wear of cutting edge for cBN coated inserts and PVD TiAlN coated inserts.

(2CBN) tools, synthesized using HPHT cBN crystals, have been proved to perform well in the machining of hardened steels and cast iron. The cBN tools possess all the required properties of a best-served cutting tool. Despite the increased use of aluminum-silicon and other non-ferrous alloys, steel and cast iron are still the most abundant material in the heavy and automotive industries. For example, machinability of cast iron depends primarily on its microstructure but also on the amount of sand in casting. The distribution of chill is and the dimensional variations due to casting defects. PCBN tools are extremely successful in machining gray cast iron, particularly in machining homogenous pearlitic castings. In spite of its superior chemical stability, cBN hard coating was far from realization due to the poor success in achieving cBN thin film synthesis with the state-of-the-art vapor deposition techniques, which includes physical and chemical vapor deposition, and hybrid techniques - those involving the mixture of the previous two techniques. Thus, the event of realizing cBN-coated tools was waiting for a major breakthrough in integrating cBN phase with thickness higher than about 500 - 800 nm. Machining hardened steel and cast iron is poised to become a major application of new cBN-coated tools. In fact, the manufacturing process flexibility and cost of these tools allow them to compete with not only PCBN but also TiAIN, multilayer and other ceramic tools. In the major award winning and patented breakthrough Duraloc and NanoMach in partnership with the University of Arkansas have developed 3D coating chemistry, unlike layered counterparts, and commercialized a hybrid coating process technology for realization of cBN composite coatings on carbide cutting tools of various designs (Fig. 1). This hybrid technology combined electrostatic coating of cBN preform followed by chemical vapor infiltration (CVI) of a binder such as TiN, TiC, TiCN, HfN, etc. allowing desired application specific chemistries, thicknesses, conformability, manufacturability and cost. Following is an overview of the application notes comparing the superior performance of the new cBN coating with state of the art, PCBN brazed and PVD TiAlN coated inserts, as well as ceramic inserts.

Application Cases for cBN Coating in Turning Engineering Materials

In the following application notes, the cBN coated tool performance was evaluated in turning engineering materials including hardened steels, pre-hardened steels, and ductile irons, and compared to its corresponding industrial benchmarks in terms of tool life and tool wear.

TURNING AISI 4340 HARDENED STEEL

The workpiece was AISI 4340 hardened steel with hardness of 50-52 HRC (L=125mm, D=62.5mm). The turning process was continuous with water-based cutting fluid. The cBN (Grade TTH-500) coated inserts were CNMA432. The benchmark inserts were all CNMA 432 for polycrystalline cubic boron nitride (PCBN), PVD TiAlN coated inserts, CVD multi-layer coated (TiN-TiCN-Al2O3-TiN) inserts, and bulk Al2O3 inserts. The machining condition applied were typically recommended for semi-finish and finish turning alloy hardened steel using polycrystalline cubic boron nitride (PCBN) tipped or bulk inserts. The conditions were also within the range recommended for the other benchmark inserts. The specific machining condition was: surface speed, V=150 m/min, feed rate, F=0.15 mm/rev, depth of cut=0.25 mm.
APOGEE is one of the fastest growing companies in the industry today with a team of dedicated professionals who possess decades of experience in drawing Tantalum, Titanium and Niobium cans and cups.

We have created a process that insures the highest quality product at a competitive price with excellent service. Every step is monitored from the purchase of raw materials to precision tooling in our own in house facility. Our unique manufacturing process insures a level of quality that has been unmatched in the industry today.

We invite you to compare our pricing, quality and customer satisfaction to see for yourself why APOGEE has become the fastest growing leader in the precision parts industry.

Please call us to discuss your individual requirements and allow us to provide you with a custom competitive quote.

APOGEE PRECISION PARTS
55 Access Road, Suite #600 • Warwick, Rhode Island 02886
(401) 732-3634 ~ Fax (401) 732-5237
Web Site www.apogeeprecisionparts.com
E-mail: davem@apogeeprecisionparts.com
The cBN Coating vs. PCBN

Figure 2 shows a comparison of tool performance between cBN-coated inserts and PCBN tipped inserts. In an important finding, cBN coated carbide inserts produced same or better tool life as compared to the PCBN chip brazed inserts, with much lower flank wear. Additionally, cBN coated carbide inserts provides various designs for chip breaker geometries, which facilitated the chip control specially for turning alloy steel with medium to high hardness. In terms of cost, cBN coated inserts cost only about 50-70% of the PCBN tools. The extended tool life and reduced cost from cBN coated inserts directly contributed to the gain higher productivity and significant cost saving. The typical flank wear of the tested cBN coated inserts and PCBN tipped inserts are shown in Figure 3. After more than 40 minutes of turning, cBN coated insert showed slight and uniform flank wear, while PCBN insert showed a notch at its trailing edge, in addition to more distinguishable flank wear compared to cBN coated inserts.

The cBN coated vs. PVD TiAlN coated inserts

PVD TiAlN coating is widely used in turning alloy steels. It is also recommended for machining alloy-hardened steel. At the aforementioned machining conditions, the tool performance of cBN coated inserts and PVD TiAlN coated inserts is shown in Figure 4. The cBN coated inserts demonstrated more than 300% of tool life extension over PVD TiAlN coated inserts. SEM examination on the tested inserts demonstrated an even flank wear and moderate crater wear of cBN coated insert, while severe flank wear and crater wear of the PVD TiAlN coated inserts as revealed in Figure 5. Additionally, the cutting edge of the PVD TiAlN coated insert was severely damaged, leading to the loss of dimensional accuracy of the workpieces.

The cBN coated vs. CVD multi-layer coated inserts

CVD multi-layer coated carbide insert is another candidate typically used for turning of hardened steels, especially rough turning of hardened steel. At the identical turning conditions, as described above, cutting performance comparison of cBN coated and CVD multi-layer coated inserts were carried out and the results are shown in Figure 6. Based on the wear criteria specified in ISO 3685, cBN coated outperformed CVD multi-layer coating by about 50%. Tool wear analysis indicated that cBN coated inserts had slight flank wear and crater wear being characteristic of abrasive wear; while CVD multi-layer coated inserts experienced severe crater wear leading to the damage of the insert substrate, in addition to non-even flank wear, as shown in Figure 7.

The cBN coated vs. bulk alumina (Al2O3) inserts

As recommended by tool manufacturers for turning hardened steel with medium and high hardness like AISI 4340, bulk Al2O3 inserts (CNMA432) were also tested as a benchmark. Figure 8 shows a comparison of the cutting tool performance between cBN coated and bulk Al2O3 inserts. Apparently, cBN coated produced 100% more tool life than bulk Al2O3 inserts based on the tool wear criteria specified in ISO 3685. Analysis of the tested inserts for tool wear indicated that cBN coating has good resistance to abrasion, while bulk Al2O3 inserts show deep grooves on the flank resulted from the abrasion of the workpiece materials, as revealed in Figure 9.

TURNING OF AISI 4140 PRE-HARDENED STEEL

The workpiece, AISI 4140 pre-hardened steel, had hardness of 25–32 HRC (D=62.5 mm, L=125mm). The turning process was continuous with water
AD INSERTION ORDER

ADVERTISING IN FINER POINTS IS THE BEST WAY TO GET YOUR PRODUCTS SEEN

FINER POINTS

“The oldest magazine dedicated solely to the technology and application of superabrasives.”

P.O. Box 29460 • Columbus, Ohio 43229 • USA
Phone: (614) 797-2265 • Fax: (614) 797-2264 • E-Mail: Tkane-IDA@insight.rr.com

The undersigned is purchasing a _____ page ad for his/her firm at $ _________ per issue for ________ times beginning with the _______________, 20____ issue.

Commissionable at 15% for recognized Ad Agencies, if invoice paid within 30 days.

Date ___________________ Signed by _____________________________________________________________________________________________________

ADVERTISER:

Company __________________________________________________  Contact _________________________________________________________________
Address ______________________________________________________________________________________________________________________________
City ________________________________________  State/Province _______________________  Country____________________________________________
Zip/Postal ____________________________  Telephone _______________________________________  FAX _________________________________________
Email _________________________________________________________________________________________________________________________________

AGENCY: ___________________________________________________  Contact_________________________________________________________________
Address ______________________________________________________________________________________________________________________________
City ________________________________________  State/Province _______________________  Country____________________________________________
Zip/Postal ____________________________  Telephone _______________________________________  FAX _________________________________________
Email _________________________________________________________________________________________________________________________________

2009 ADVERTISING RATES

Please check size of advertisement desired. You will be invoiced
HOLDING YOUR ADVERTISING RATES THE SAME FOR ANOTHER YEAR!

<table>
<thead>
<tr>
<th>Frequency</th>
<th>1X</th>
<th>4X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-page, 7-1/2&quot;W x 10&quot;H, 4 Color</td>
<td>$2110</td>
<td>$1820</td>
</tr>
<tr>
<td>Full-page, 7-1/2&quot;W x 10&quot;H, Black/2nd Color</td>
<td>$1820</td>
<td>$1530</td>
</tr>
<tr>
<td>Full-page, 7-1/2&quot;W x 10&quot;H, B &amp; W</td>
<td>$1570</td>
<td>$1425</td>
</tr>
<tr>
<td>Half-page, 5&quot;W x 7-1/2&quot;H, Four Color</td>
<td>$1240</td>
<td>$1090</td>
</tr>
<tr>
<td>Half-page, 7-1/2&quot;W x 5&quot;H, Four Color</td>
<td>$1240</td>
<td>$1090</td>
</tr>
<tr>
<td>Half-page, Either Size, Black/2nd Color</td>
<td>$1090</td>
<td>$ 950</td>
</tr>
<tr>
<td>Half-page, Black &amp; White</td>
<td>$ 950</td>
<td>$ 875</td>
</tr>
<tr>
<td>1/3 page, 2-3/8&quot;W x 10&quot;H, 4 Color</td>
<td>$1020</td>
<td>$ 950</td>
</tr>
<tr>
<td>1/3 page, 2-3/8&quot;W x 10&quot;H, B &amp; W</td>
<td>$ 875</td>
<td>$ 800</td>
</tr>
<tr>
<td>1/4 page, 4-3/4&quot;W x 4-3/4&quot;H, B &amp; W</td>
<td>$ 800</td>
<td>$ 730</td>
</tr>
<tr>
<td>Back Cover, Full-page, 4 Color Only</td>
<td>4X Only</td>
<td>$2985</td>
</tr>
<tr>
<td>Inside Front Cover, Full-page, 4 Color Only</td>
<td>4X Only</td>
<td>$2839</td>
</tr>
<tr>
<td>Inside Back Cover, Full-page, 4 Color Only</td>
<td>4X Only</td>
<td>$2766</td>
</tr>
</tbody>
</table>

Additional Charges (non-commissionable):

| BLEED (full page - 8-3/4" x 11-1/4") | $125 additional charge |
| PAGE SELECTION | $175 additional charge |

IDA MEMBER RECEIVES 10% AD DISCOUNT

Classified ad rates are Non-commissionable $85, members/$125, non-members ________ All 2-1/4"W x 2-1/4"H

2009/2010 EDITORIAL CALENDAR

Planned issues, topics and closing dates:

<table>
<thead>
<tr>
<th>Issue</th>
<th>Editorial Feature*</th>
<th>Closing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall 2009</td>
<td>CVD Diamond &amp; cBN</td>
<td>Aug. 31, 2009</td>
</tr>
<tr>
<td>Winter 2009/2010</td>
<td>Polycrystalline cBN and Diamond</td>
<td>Nov. 30, 2009</td>
</tr>
<tr>
<td>Summer 2010</td>
<td>IMTS Preview &amp; Machine Tools</td>
<td>June 30, 2010</td>
</tr>
<tr>
<td>Fall 2010</td>
<td>INTERTECH 2011 Preview</td>
<td>Aug. 31, 2010</td>
</tr>
</tbody>
</table>

*Editorial topics subject to change

SHIPPING INSTRUCTIONS

Fax, mail or email all printing materials to:

Production Manager
FINER POINTS MAGAZINE
P.O. Box 29460
Columbus, Ohio 43229 USA
Phone: 614-797-2265
Fax: 614-797-2264
E-Mail: tkane-ida@insight.rr.com
based cutting fluids. The inserts were CNMG432 coated with cBN (Grade TTPH-300). Benchmark inserts used for comparison were CVD multi-layer coated CNMG432 from different sources. The machining conditions were $V=183$ m/min, $F=0.41$ mm/rev and $DcC=1.78$ mm, which are typically recommended for rough turning. At identical machine setting and machining conditions, cBN coated (Grade TF-300) coated inserts outperform CVD multi-layer coated inserts from different vendors by at least 50%, as shown in the Figure 10 and cBN coated inserts are equivalent to CVD multi-layer coating in cost.

**TURNING NODULAR CAST IRON**

The workpiece had a hardness of 150-180 HB. The inserts were cBN coated (TTNC-300) CNGA 433 carbide inserts. Benchmark inserts used for machine performance comparison were CVD A203 coated CNGA433 carbide inserts. The machining tests were carried out in turning nodular cast iron (ferrous ductile iron) at the conditions listed in the Table 1. The findings of the testing results are shown in Figures 11 (A), (B), and (C), respectively. The cBN coated outperformed the benchmark inserts by 30-75%, respectively.

**Coating Analysis and Discussion**

The tested cBN coated inserts, coated with cBN-TiN composite, were with different cBN particulate density over unit volume. The coating design combined the super-hardness of cBN particles along with the lubricity of TiN, making it suitable for machining of the engineering materials. The composite coating adhered well to the substrates of tungsten carbide (WC) with various cobalt (Co) percentages. As well as cBN particles bind very well to the binder phases. More information could be found in the following list of published literature. SEM analysis of the cBN coating cross section showed fairly uniform thickness with cBN particles (black dots) uniformly distributed in the TiN matrix across the coating, as shown in Figure 12. The composite coating is uniquely designed with cBN-TiN composite coating to provide the wear resistance and capped using a layer of TiN that offered the lubricity and superior crater wear resistance. All the machined samples provided on par or better surface finish in comparison to the benches marks. X-ray diffraction (XRD) analysis clearly showed the signature of cBN, without any traces of unwanted

**FIGURE 10:** Comparison of tool performance in continuous turning AISI 4140 pre-hardened steel between cBN coated and CVD multi-layer coated inserts.

**FIGURE 11:** A comparison of tool performance in continuous turning nodular cast iron at (A) $V=244$ m/min, (B) $V=274$ m/min, and (C) $V=305$ m/min, respectively, between cBN coated and CVD Al2O3 coated inserts.
MEMBERSHIP APPLICATION

Company ___________________________ Address ___________________________
City ___________________________ State ______ Zip Code/Postal Code ______ Country ______
Shipping Address (Can not ship to PO Box) __________________________________________________________________________
City ___________________________ State ______ Zip Code/Postal Code ______ Country ______
Phone __________________ Fax ___________ E-mail ___________________________
E-mail ___________________________ Web Site ____________________________________________________________________________
Official Representative ________________________________________________________________________________________________

Name of 3rd Affiliate Member ($95): _______________________________________
Name of 2nd Affiliate Member ($95): _______________________________________
Name of 1st Affiliate Member (no charge): __________________________________

When was your company established? ______________ List at least two business references, preferably one is an IDA member (name, company and address of each):
1. ____________________________________________________________________
2. ____________________________________________________________________

How long has your company been engaged in superabrasive/ultra-hard material industry? __________

CHECK APPROPRIATE MEMBERSHIP

Regular Membership
Any company and/or individual classified as a superabrasive/ultra-hard material supplier, tool maker, machine tool builder, end user or related business with offices in the USA, Canada or Mexico is eligible in this category. Only one individual shall be designated by each member company as the IDA Delegate with voting and other privileges described in the By-Laws.

The dues category for Regular Members is determined by annual sales volume expressed in US $ as indicated below. Check to appropriate category:

(DUES CATEGORY)

Category 1 $2,575 per year
Under $2,000,000 Annual Sales

Category 2 $1,536 per year
$2,000,000 - $5,999,999 Annual Sales

Category 3 $1,709 per year
Under $1,999,999 Annual Sales

Category 4 $1,328 per year
CVD Diamond and cBN Coating

Category 5 $973 per year

If the delegate cannot vote at any membership meetings, participate in statistical reporting for the North American market, hold proxies or serve in any office in IDA. Annual fee for International Member is $2,575 per year.

Name of Delegate Voting Member: ________________________________________
Title: ___________________________ E-Mail: ______________________________

International Membership
Any company and/or individual classified as a superabrasive/ultra-hard material supplier, tool maker, machine tool builder, end user or related business which does not have offices or other facilities in the USA, Canada or Mexico is eligible in this category. An International Member shall have all the privileges of regular membership, except that the delegate cannot vote at any membership meetings, participate in statistical reporting for the North American market, hold proxies or serve in any office in IDA. Annual fee for International Member is $2,575 per year.

Name of Delegate Voting Member: ________________________________________
Title: ___________________________ E-Mail: ______________________________

Associate Membership
Available for companies having a principal office in the USA, Canada or Mexico, which are providing products or services to the superabrasive/ultra-hard material industry, but are not engaged in selling, using or dealing in industrial diamonds, cubic boron nitride, compacted diamond/cbn, diamond film or products containing diamonds/cbn. An Associate Member shall have all the privileges of regular membership, except that the delegate cannot vote at any membership meetings, participate in statistical reporting for the North American market, hold proxies or serve in any office in IDA. Annual fee for Associate Member is $500 per year.

Name of Delegate Voting Member: ________________________________________
Title: ___________________________ E-Mail: ______________________________

Affiliate Membership
Each company that enrolls as a Regular or International IDA Member is entitled to have a second person at that company designated an Affiliate Member. The first Affiliate member will receive IDA material at no further cost. Additional persons at Member companies can be added as Affiliate Members to receive IDA materials. Annual fee for Affiliate Member is $75 per year.

Name of 1st Affiliate Member (no charge): ____________________________________
Name of 2nd Affiliate Member ($95): ________________________________________
Name of 3rd Affiliate Member ($95): ________________________________________
If more than 3 Affiliate Members, please attach separate sheet.

Education/Research
Any individual having an affiliation with a non-profit educational institution or Research & Development organization is eligible for membership in this category. An Education/Research Member shall have all the privileges of regular membership, except that the delegate cannot vote at any membership meetings, participate in statistical reporting for the North American market, hold proxies or serve in any office in IDA. Annual fee for Education Member is $125 per year.

Senior Membership
Available for any individual who has retired and is no longer active in the diamond or cbn business, but wishes to receive information mailings and attend IDA meetings as a member. Annual fee for Senior Member is $50 per year.

WHAT IS THE IDA?
The Industrial Diamond Association of America, Inc. is a non-profit trade association and was incorporated on March 29, 1946 in the State of New York. It is the oldest and most prestigious association in the superabrasive/ultra-hard materials industry. Activity and focus has evolved from natural diamond to super abrasives and most recently, to all ultrahard materials including CVD Diamond. Members include material suppliers, tool manufacturers, component producers, machine tool builders, end users, academia/research affiliates and other companies related to the research, manufacture, application, use and sales of superabrasives.

WHAT DOES THE IDA DO?
◆ Oversees Statistics Reporting Program
◆ Establishes Industry Standards
◆ Interacts With Global Associations And Organizations
◆ Creates And Distributes Market Studies & Data
◆ Organizes And Presents Technical Seminars & Conferences
◆ Serves As A Government Liaison For Industry Guidelines And Regulations
◆ Participates As Member Of World Diamond Council
◆ Provides Safety / Regulatory Reports And Advisement
◆ Resource For General Information And Consultation

OTHER MEMBER SERVICES
◆ PUBLISHES QUARTERLY MAGAZINE
◆ HOLDS ANNUAL CONVENTIONS
◆ HOSTS IDA WEBSITE WITH MEMBER FOCUS AND DIRECTION
◆ PROVIDES SPECIFIC ASSISTANCE ON INDIVIDUAL MEMBER ISSUES
◆ CREATES AND DISTRIBUTES PUBLICATIONS ON PRODUCTS AND APPLICATIONS
◆ ACTS AS A COLLECTIVE VOICE FOR INDUSTRY CONCERNS

FAX COMPLETED MEMBERSHIP FORM TO 614-797-2264
TABLE 1: Machining condition for turning nodular cast iron (with water-based cutting fluid)

<table>
<thead>
<tr>
<th>No.</th>
<th>SURFACE SPEED (m/min)</th>
<th>FEED RATE (mm/rev)</th>
<th>DEPTH OF CUT (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>244</td>
<td>0.25</td>
<td>2.0</td>
</tr>
<tr>
<td>2</td>
<td>274</td>
<td>0.25</td>
<td>2.0</td>
</tr>
<tr>
<td>3</td>
<td>274</td>
<td>0.25</td>
<td>2.0</td>
</tr>
</tbody>
</table>

hexagonal and amorphous phases of BN, confirming that the innovative cBN coating manufacturing process does not degrade key cBN phase. Scratch tests run across calo crater provided critical loading as high as 20 kg without local failure. SEM analysis of the tested inserts showed that cBN particles are retained in the TiN matrix on the worn flank surface without any sign of coating delamination (Figure 13) and sub-micron to micron sized crack formation at particle-binder interfaces, confirming that there is good particle-to-binder adhesion in addition to good adhesion between coating and substrate. The unique “3D” coating chemistry design and excellent adhesion provide the strategic properties required for superior tool life in turning the respective highlighted materials in the above discussion.

CONCLUSION

Based on all the tests carried out for the application cases, cBN coating of various grades outperformed their respective industrial benchmark inserts in continuous turning of AISI 4340 hardened steel, AISI 4140 pre-hardened steels, and nodular cast iron. During all the tests, the cBN coating adhered well to the substrate demonstrating superior resistance to abrasive wear. In particular, cBN (TTH-500) coating produced at least the same tool life as PCBN tipped inserts in turning AISI 4340 hardened steel, while its cost is only about 50-70% of that of PCBN inserts, resulting in significantly cost saving. The new cBN coating also produced significantly longer tool life when compared with PVD TAIN coating, CVD multi-layer coating, and bulk Al₂O₃ inserts in continuous turning AISI 4340 hardened steel, indicating the superiority of the coating over the widely used coatings or ceramic inserts. The super performance from the new cBN coated inserts in turning AISI 4140 pre-hardened steel and nodular cast iron demonstrating the wide potential for machining other engineering materials. There is currently a ramping up of the scaled up production as well developing new grades for other significant as well as specialty application markets.

For more information and details contact Dr. Malshe at: ajay.malshe@nanomach.biz or visit: http://www.duralum.com
With Specialized Diamond Powders from Engis...

Confidence Runs Deep.

To create the most consistent, reliable diamond powder on the market, Engis' experience goes deeper, utilizing an unsurpassed understanding of diamond properties that extends far beyond particle size characterization.

At Engis, we know that at the heart of the most complex and precise diamond applications, there is an elegantly simple equation:

\[ \text{Properties} = \text{Performance} \]

Each micron diamond powder is designed, manufactured and qualified to possess the specific set of size, shape, chemical and physical properties that are responsible for its elevated performance in specific applications, including PCD manufacturing, hard disk drive manufacturing, and the manufacturing of compounds, slurries and tools for general abrasive applications.

That's why our customers trust Engis diamond powders to accelerate throughput, increase yields and attain higher levels of precision.


For the finest specialized diamond powder, bar none, contact Engis today.

1-800-99-ENGIS

www.engis.com/powder

ENGIS CORPORATION • 105 West Hintz Road • Wheeling, IL 60090
Tel: 847-808-9400 • Fax: 847-808-9430 • E-mail: sales@engis.com

Leaders in Superabrasive Finishing Systems
Diamond Abrasives Corporation, DAC, is changing its name to Element Six.

DAC is one of the leading industrial diamond companies in the US with 40 years of history behind it. Now that is added to Element Six, which has more than 50 years of leadership in the industrial diamond business. The combined experience will now be of benefit to US customers in all industrial diamond markets.

The name change recognizes the fact that DAC is now an integral part of Element Six, an international group operating in more than 70 countries with both technical and market leadership that can deliver real benefits to our US customers. Such benefits include increased links to the company’s global manufacturing capabilities, application technical and development expertise across many industries.

As Element Six we are the world’s leading supplier of diamond supermaterials. We are the frontrunner in the development of synthetic diamond and novel related engineering materials spanning for example optical, mechanical, thermal and electronic thermal properties for application in such diverse industries as aerospace, automotive, chemical and construction, defence, energy, medical, oil & gas, telecommunications and technologies.

With a turnover of US$ 500m in 2008 and almost 3,000 employees, Element Six has global production and processing plants supported by sales and distribution networks. You can now buy our products online. Visit www.e6.com

Element Six
35 West 45th Street
7th Floor
New York, NY 10036
Email: usadvancedmaterials@e6.com

Element Six – leading the way in industrial diamond