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MODERN DEVELOPMENTS RELATED TO THE DIRECTED IMPACT ON THE CUTTING SURFACE OF A DIAMOND ABRASIVE TOOL AND ITS CONTACT ZONE IN THE PROCESSES OF MACHINING (REVIEW)

Abstract. *This article provides information on modern developments in the direction of directed impact on the cutting surface of a diamond-abrasive tool and its contact zone in machining processes. For the most part, such processing is faced with issues of influence on the cutting surface of diamond tools, including ruling mechanical and electrophysical, taking into account the defectiveness of the diamonds that undergo processing, the directed influence on the surface of such diamonds, thermal and modification of the surface of diamonds. Such developments make it possible to significantly intensify processing processes and increase the efficiency of the diamond abrasive tool. That is why, in this review, the main attention is paid to the presentation of modern developments, known from scientific publications, mainly for the last 5 years, related to the above-mentioned issues.*

Keywords: *diamond abrasive tool; cutting surface; contact zone; mechanical processing; defects of diamonds; electrophysical influence.*

1. Introduction

High-hard and high-strength materials, especially tool materials, are now widely used in industry. Their effective diamond processing is important for modern production. At the same time, the issue of effective processing, along with instrumental processing, of such fragile, difficult-to-process materials as mono- and polycrystalline diamonds, including CVD diamond films, sapphire, etc. For the most part, such processing is faced with issues of influence on the cutting surface of diamond tools, including ruling mechanical and electrophysical, taking into account the defectiveness of the diamonds that undergo processing, the directed influence on the surface of such diamonds, thermal and modification of the surface of diamonds. Also, great attention is paid to obtaining a high-quality defect-free surface processed layer of the above-mentioned difficult-to-process materials. That is why, in this review, the main attention is paid to the presentation of modern developments (mainly over the last 5 years) related to the above-mentioned issues.

2. Processing of brittle mono- and polycrystalline materials

At the beginning of this review, let's pay attention to the development of a grinding wheel with a diameter of 3.2 mm, which was made of nanopolycrystalline diamond (NPD), obtained by direct conversion sintering under high pressure and temperature [1]. Using this NPD wheel as a grinding blade, a new useful method for investigating the micro-scale abrasive properties of single-crystal diamonds was developed. Since NPD has an extremely high hardness of about 130 GPa, the abrasive properties of various natural and synthetic single-crystal diamonds, whose hardness is usually around 70 to 125 GPa, can be appropriately evaluated. In addition, since the wheel diameter is very small, it is possible to measure the abrasion resistance in a minute region of several tens of μm in a diamond crystal. It was confirmed that the method can accurately evaluate the abrasive properties of minute regions of single-crystal diamonds using synthetic type IIa diamond. It was also demonstrated that it is possible to investigate how the abrasive properties of synthetic type Ib and natural type Ia diamonds change depending on the distribution of impurities or crystal defects in the crystals [1].

In work [2], a smooth nano-sized surface of polycrystalline diamond without damage was polished, on the contrary, with a rough diamond (D151) grinding wheel on a ceramic bond. Atomic force microscopy verified that surface roughness of S_a 4.20 nm, S_a 2.06 nm, and S_a 0.548 nm were achieved under grinding speeds of 750, 1050, and 1350 rpm, respectively. Electron energy loss spectroscopy spectra confirmed the existence of a graphitic layer (black layer) with a thickness of ~15 nm in the subsurface after grinding. The “black layer” showed an easy ability to be removed under scratch and high-temperature oxidation. Moreover, transmission electron microscopy demonstrated that no damaged layer was observed in the subsurfaces at 750 rpm and 1050 rpm grinding speed. For grinding speed of 1350 rpm, stacking faults and micro-crack appear in the subsurface, thus forming a damaged layer with several microns in thickness. This work [2] demonstrates a unique removal mechanism for abrasive processing of hard-and-brittle materials, as distinct from either mechanical grinding or chemical mechanical grinding.

In the article [3], the grinding of monocrystalline diamond substrates, which must have a super-smooth surface (atomic-order), was investigated. Known methods of polishing single crystal diamonds are based on pressure control processes and are capable of improving surface quality, but are inefficient. To obtain high-precision surface smoothness with greater process efficiency, the authors [3] have developed a method for diamond polishing that is based on a depth-control principle and employs an ordinary rotary grinder in which both the substrate and the grinding wheel are rotated simultaneously during the grinding. The resulting ground surface showed tiny crosshatch scratches. By progressively applying finer grinding wheels from #600 to #15000, the surface could be gradually improved, and finally a surface with a near-atomic-order surface roughness was obtained with the finest wheel (#15000); the average surface roughness was 0.13 nm for 5 × 5 μm^2 area. The removal rate with the #15000 wheel was 0.04 μm/min, which was markedly higher than that achievable by other methods capable of producing an atomic-order surface roughness on single-crystal diamond. The depth of subsurface damage induced by the grinding process was reduced by using finer grinding wheels. The processed surface was ultrasmooth with ~0.1 nm average surface roughness.

Polishing of polycrystalline diamond using the synergy of chemical and mechanical influences is considered in work [4]. Polycrystalline diamond (PCD), applied in the form of a thin film, is an attractive material due to the unique combination of its properties. But, since for many of its applications it is necessary that the PCD has a high quality of surface treatment, effective and economical polishing is important. In article [4], chemical-mechanical polishing of PCD is considered. Three main ways of material removal during diamond polishing are identified and summarized on the basis of experimental results: interphase mechano-chemical removal, chemically stimulated mechanical removal and mechano-chemical transformation of diamond.

The work [5] is focused on highly efficient and damage-free diamond polishing enhanced by atmospheric pressure inductively coupled plasma (ICP) modified silicon plate. A rapid decrease in the surface roughness from S_a 308 nm–0.86 nm over 300 μm^2 in 120 min proclaims ICP enhanced polishing a highly efficient technique (Fig 1). Simultaneously, an atomically smooth, high-quality diamond surface is obtained with a surface roughness of R_a 0.26 nm over 20 μm^2. The polishing mechanism based on the OH-modification of silicon plate and diamond surface, dehydration condensation reaction occurring at the interface of OH-terminated surfaces, and subsequent mechanical shearing of carbon, is proposed. TEM and Raman analysis of polished surfaces confirm that the use of ICP contributes to further damage-free removal of the mechanically caused damaged layer [5].

Ultrahard nanotwinned diamond (nt-D) is an ideal material for next-generation high-precision, high-efficiency cutting tools, due to its high hardness, enhanced fracture toughness, and increased oxidation resistance temperature, when compared with natural diamond. However, a critical problem that limits the application of such material is the grinding and polishing of nt-D material into suitable shapes. In article [6] confirmed the feasibility of classical mechanical polishing for nt-D through amorphization transition. The effect of mechanical loading and the catalysis of Fe nano-particles work together, promoting the transformation of nt-D into a hard sp^2–sp^3 amorphous carbon (Fig. 2). The surface of the amorphous carbon layer and the interface between amorphous carbon and nt-

D were both smooth after polishing. The results are valuable for the mechanical processing and further applications of ultrahard nanotwinned diamond.

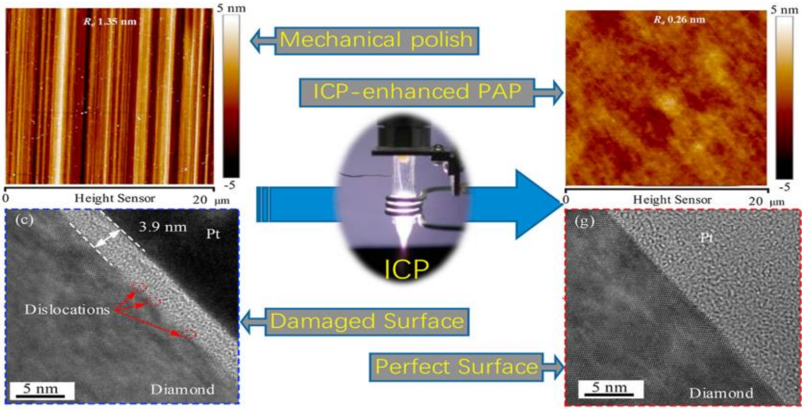


Figure 1 – Scientific principles underlying the mechanism of polishing single-crystal diamond enhanced by inductively coupled plasma [5]

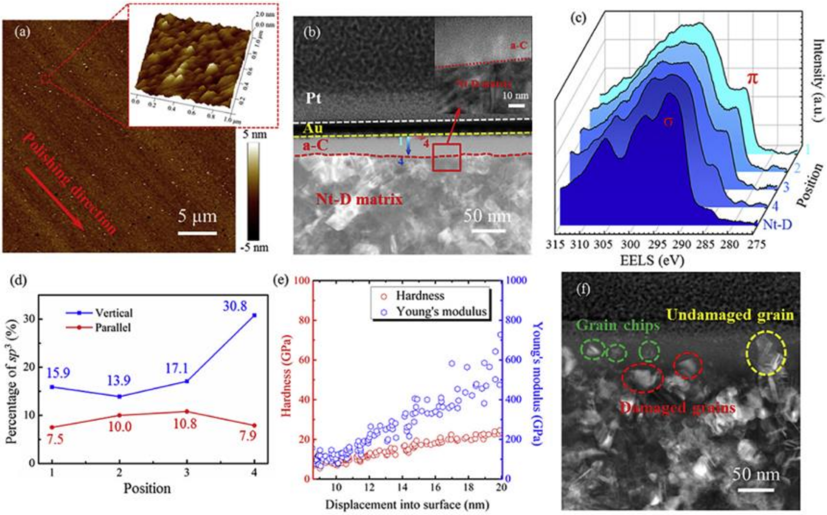


Figure 2 – Scientific principles underlying the mechanism of mechanical polishing for nt-D through amorphization transition [6]

Monocrystalline diamond possesses covalent bonding making diamond extremely hard and difficult to machine. In study [7] a microdiamond stylus typically used in measuring surface roughness is machined to exemplify the proposed ‘microspark erosion-assisted machining with heat-avoidance path’ technique. Based on the high thermal conductivity and weak electrical conductivity of boron-doped monocrystalline diamond, high-frequency pulsed discharge plasma is employed to efficiently perform microspark erosion machining on an extremely hard monocrystalline diamond blank. It was found that the pulse-on time and servo voltage respectively affect erosion plasma length and the erosion gap during diamond machining. Also, the safety distance and safety height of the erosion path dominate heat transfer to filler metal. These factors all affect the firmness of the brazed diamond blank on the substrate. Three mechanisms for removing carbon atoms from the diamond blank surface were observed. They are vaporization, melting, and graphitization of carbon atoms. This graphitized carbon atoms have weak electrical conductivity, which is conducive to inducing the wire-electrode to generate a greater electric field and secondary discharging, facilitating removal of additional carbon atoms. Experimental results indicate that a microdiamond stylus prototype with a tip of 10 µm can be safely formed using a ‘microspark erosion-assisted machining with heat-avoidance path’ technique, creating 93.7% repeatability of the minimum residual stylus diameter. The tangential micro-grinding facilitates the stylus tip to receive grinding from the grinding wheel's maximum tangential speed and create the precision microdiamond stylus with 1 µm in tip-radius (Fig. 3). The applied microspark erosion-assisted machining had a diamond material removal rate that was 54% more efficient than conventional grinding of a commercial microdiamond stylus. The formed microdiamond stylus was inspected by Raman spectroscopy and verified by the surface roughness standard gauge to be up to industry standards.

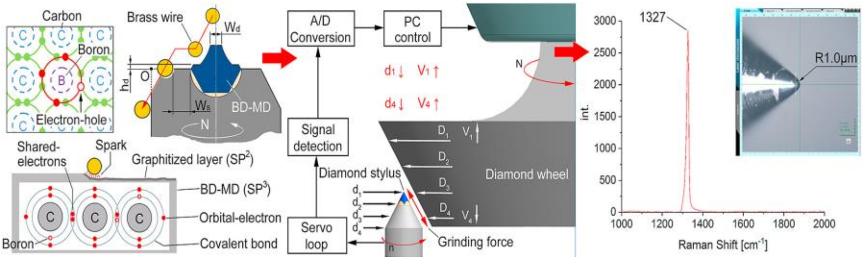


Figure 3 – Microdiamond stylus prototype with a tip of 10 μm can be safely formed using a ‘microspark erosion-assisted machining with heat-avoidance path’ technique and create the precision microdiamond stylus with 1 μm in tip-radius [7]

Above, we drew attention to the effect of boron impurities in diamond on its conductivity, so at the end of this part of the review, we will review the wear characteristics of cubic boron nitride grains during abrasive wear [8]. The wear phenomenon is an important issue that affects the grinding performance of polycrystalline cubic boron nitride (PCBN) grinding wheel. To explore the wear mechanism, single grain scratching tests were conducted on the nickel-based superalloy Inconel 718. Fractal theory was applied to evaluate the grain wear process, and the influences of undeformed chip thickness $a_{g\max}$ and grinding wheel speed v_s on grain wear were analysed. The variation in fractal dimension, grinding force and grinding force ratio were discussed. Results show that the micro-fracture is caused by the crack, and the adhered grinding chip leads to the attrition wear of PCBN grain. The average specific material removal volume of monocrystalline CBN grain is approximately 10.7% that of PCBN grain when macro-fracture occurs. The effect of a_{gmax} on grain macro-fracture is stronger than that of v_s. Furthermore, the grinding parameters should be set as follows: v_s of 80 m/s and a_{gmax} in the range of 0.1–0.67 μm. These settings help improve the grain micro-fracture phenomenon in high-speed grinding [8].

3. Features of precision adjustment of diamond abrasive wheels

Now let's move on from the above-mentioned modern studies of the wear characteristics of individual diamond grains to modern developments in precision straightening of diamond wheels, in which diamond grains are located.

The rapid wear of the dressing tools severely limits the further improvement of the truing accuracy and dressing sharpness of the arc-shaped diamond wheels used in ultra-precision grinding. In paper [9] thoroughly investigated the wear characteristics of electroplated diamond dressing wheels used for on-machine precision truing of arc-shaped diamond wheels. Firstly, wear topography and protrusion height of the diamond particles were researched. Secondly, the wear evolution mechanism of diamond particles with different grain sizes was systematically researched. Then, the wear mechanism of the metal bonded matrix was studied (Fig. 4). Subsequently, the Raman spectrum analysis of diamond particles before and after wear was carried out. Finally, the profile accuracy and surface topography of the trued arc-shaped diamond wheel were evaluated for distinguishing the wear resistance and sharpening performance of the electroplated diamond dressing wheels with different grain sizes.

The work [10] is devoted to the influence of the properties of grains and dressing on grinding mechanics and wheel performance: analytical assessment framework. This paper introduces an analytical assessment framework for evaluating grinding wheel performance derived from the model of cutting and sliding grinding force components. Four new parameters are proposed based on wheel topography. These parameters are normalized through the aggressiveness number, which circumvents the influences of grinding geometry and kinematics. The framework is validated through experiments with different wheel topographies obtained by changing dressing conditions and grit properties (toughness, thermal stability and shape). The framework and experiments quantify how wheel wear flat area influences the sliding component and how grit protrusion influences the intrinsic specific grinding energy. This framework provides a rational basis for evaluating grinding-wheel performance and abrasive-grit selection.

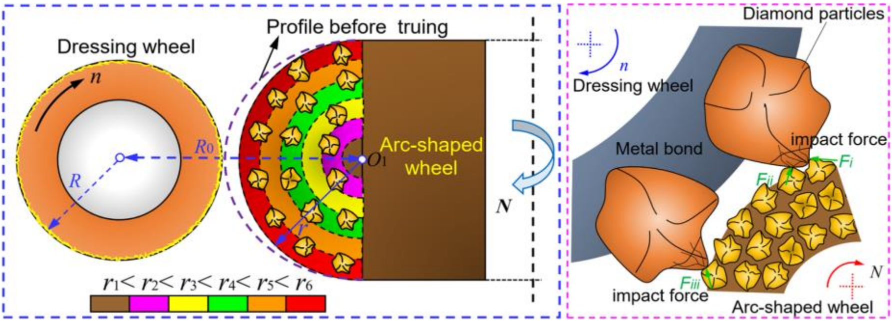


Figure 4 – Scheme of the truing of arc-shaped diamond wheels [9]

Precision grinding with ultrathin arc-shaped diamond (UAD) grinding wheels provides a satisfactory solution for the fabrication of high-quality microstructures on tungsten carbide (WC) molds. However, ultrathin grinding wheels are difficult to be trued, due to the limited small grinding wheel profile. In paper [11], an on-machine truing method for ultrathin arc-shaped diamond grinding wheels is proposed. First, a model of the three-axis linkage controlling truing for the diamond grinding wheel was introduced. Then, the effects of the setting and measurement errors of the grinding wheel on the profile radius were theoretically analyzed. Furthermore, an aspherical microstructure array of tungsten carbide was ground by the trued diamond grinding wheel. The experimental results demonstrated that the expected arc radius of the grinding wheel could be achieved and the binderless tungsten carbide mold could be ground efficiently and precisely. The profile error of the grinding wheel (diameter of 23 mm, thickness of 0.38 mm) reached 8.5 μm. An aspherical microstructure array surface of tungsten carbide with a form accuracy of 15 μm was obtained by grinding with the trued diamond grinding wheel without additional compensation [11].

In paper [12,13] a modified U-Net neural network was used to evaluate the laser sharpening quality of diamond grinding wheels, and the laser sharpening parameters were optimized. The three-dimensional (3*D*) detection algorithm is researched, and a 3*D* detection algorithm for the diamond wheel surface matching the two-dimensional (2*D*) image and the 3*D* point cloud was proposed. The recognized 2*D* grain image is filtered to remove edge grains and connected grains, correct the 3*D* point cloud by eliminating the effect of curvature, and match grain pixels (Fig. 5). The laser sharpening experiment of the bronze-bonded diamond wheel was carried out by the orthogonal experiment method, and the quality evaluation of the laser sharpening pictures of the wheel obtained by the experiment was carried out. The embedding depth of the abrasive grains was obtained from the 2*D* area of the abrasive grains, and the evaluation index of abrasive grain height-depth distribution was proposed. The laser sharpening experiments was carried out to obtain grinding wheels with different sharpening qualities, and the grinding tests were carried out. The effectiveness of the sharpening evaluation index was verified by the amount of grinding force when grinding the workpiece and the surface roughness of the workpiece after grinding. The optimal dressing process parameters were obtained as the average power of 35 W, the repetition frequency of 100 kHz, the rotational speed of 300 r/min, and the scanning speed of 3.6 mm/min.

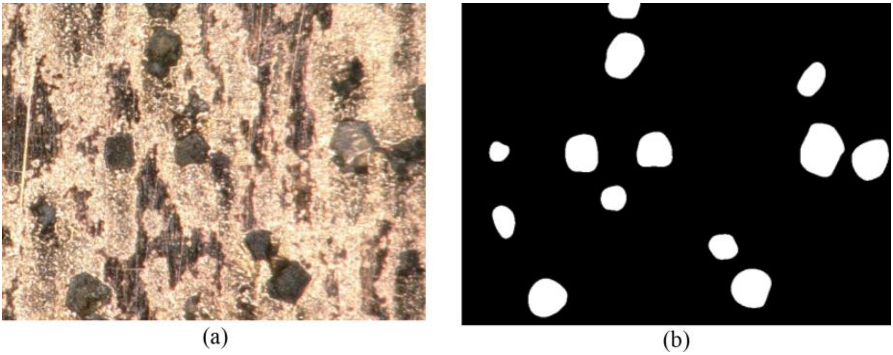
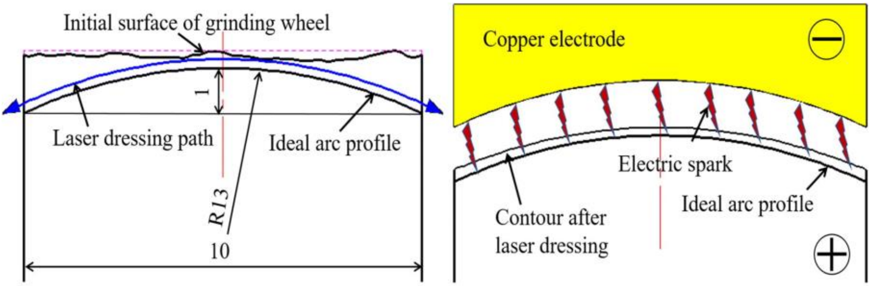

(a) (b)

Figure 5 – General view of the cutting surface of the wheel (a) and recognized 2D grain image (b) [12]

Affected by the characteristics of laser Gaussian beam, the spot size and laser energy irradiated on the grinding wheel surface change at any time with the dressing path, which makes it difficult to realize the dressing of high-precision arc-shaped diamond grinding wheel. In order to achieve high-efficiency and precise dressing of arc-shaped diamond grinding wheels, a composite dressing method using laser rough dressing and electrical discharge precision dressing was first proposed (Fig. 6) [14]. Laser rough dressing method is used to quickly remove the excess abrasive layer to obtain an arc-shaped profile. Electrical discharge precision dressing not only improved the accuracy of arc-shaped contour, but also realized the grinding wheel sharpening. The optimization of kinematic parameters on the dressing profile accuracy in laser dressing and electrical discharge dressing was explored. An arc-shaped profile with a radius of 13 mm was tested on a diamond grinding wheel with a grain size of 120#. The radius of the final dressed arc-shaped profile is 13,007 µm, and the PV value of the profile error is 10.67 µm. It was found that the abrasive grains on the surface of the grinding wheel were slightly graphitized. The damage degree of the abrasive particles in laser dressing was more serious than that of in electrical discharge dressing. Most of the graphite layer on the surface of abrasive particles could be removed by grinding alumina ceramics. The fitting radius of the arc profile of the workpiece is 13.013 mm, and the profile error PV value is 11.91 µm.



(a) Laser rough dressing (b) electrical discharge precision dressing

Figure 6 – Scheme of laser rough (a) and electrical discharge precision (b) dressing [14]

Although significant work has been done on the application of acoustic emission (AE) to grinding and to dressing of grinding wheels, several fundamental AE relationships between have not been established. These are: 1) the relationship between dressing energy and the measured AE signal; 2) how different diamond/grit contact modes (fracture, plastic deformation, rubbing, etc.) affect AE energy; and 3) how this can be used to quantify dressing efficiency, wheel sharpness and wear-induced changes in diamond shape. In paper [15] describes an investigation into these fundamental concepts, with quantification of the relationship between AE intensity and dressing energy and the influence of different diamond/grit contact modes. A new parameter is introduced, the *specific* *acoustic-emission dressing energy*, which can be used to quantify dressing efficiency and wheel sharpness. Finally, the use of the AE intensity in evaluating diamond wear is explored, allowing the operator to know the size of the wear flat and when changes are necessary to avoid workpiece burn.

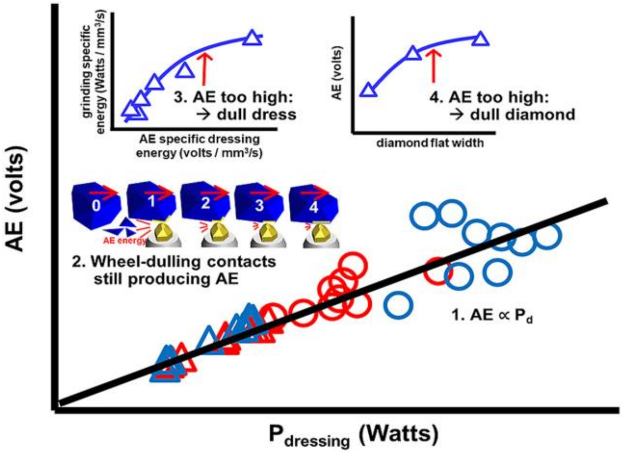


Figure 7 – Scientific principles underlying the mechanism of AE during correction [15]

4. Research on directional impact on the cutting surface of a diamond wheel and its contact zone

To improve the durability and self-sharpening ability of traditional coated abrasives for efficient automated manufacturing, structured patterns and super hard materials were utilized for the fabrication of coated tools. In study [16], the polymer matrix was synthesized by 50 wt% polyurethane and 50 wt% epoxy, the tensile strength and elongation at break is 53.6 MPa and 36.8%, respectively. Then the thermosetting PU/EP diamond composites were prepared by roller embossing successfully (Fig. 8).

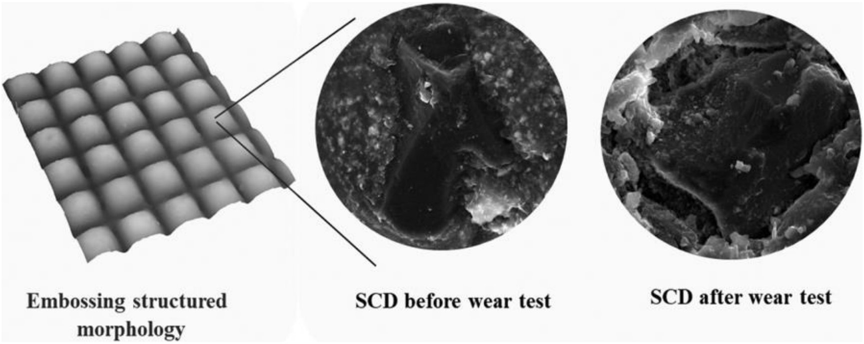
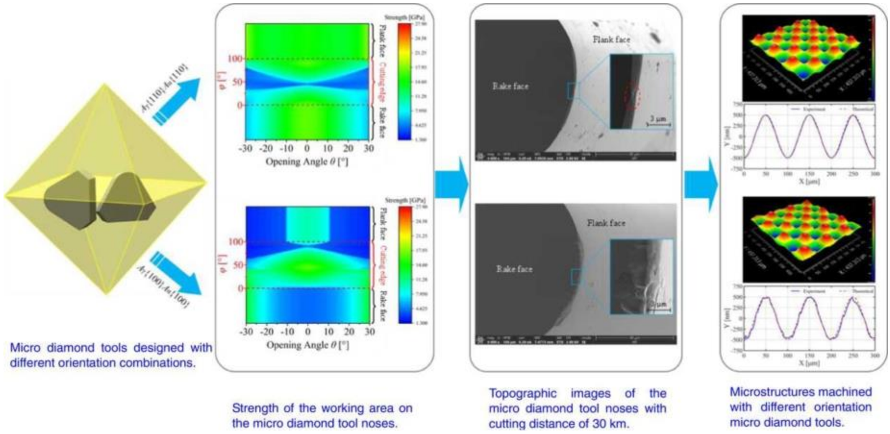


Figure 8 – Technological features of the surface of thermosetting diamond wheels made by roller embossing [16]

The wear performance tests of the composites were performed with the difficult-to-machine material 304 stainless steel. The maximum height of the summit of the 400# and 800# diamond composite grits declined by 13.6% and 8.2%, respectively after wear tests. Also, the composite grits could retain material removal ability and renew themselves due to the domed pyramid structure. The surface roughness of the workpiece decreased to 0.405 μm by 80% after the first wear test for 400# diamond and eventually approached 0.036 μm. The improvement on the surface of the workpiece could be accomplished in no more than 90 s [16].

Micro diamond tools are indispensable for machining microstructured arrays. The cutting edge durability and consistency of micro diamond tools are the determinants of the microstructure quality and accuracy, in addition to the motion accuracy of the machine tool. In article [17] a strength distribution model of the working area including the cutting edge and rake and flank faces was established considering diamond anisotropy and chip flow direction. Comprehensive wear resistances of micro diamond tools with different crystal orientation combinations were analyzed based on the model, and the wear prone areas of different tools were successfully predicted. The evolution processes of the sharpness and wear topography were monitored for every micro diamond tool in the micromachining experiments (Fig. 9).



Micro diamond tools designed with different orientation combinations.

Strength of the working area on the micro diamond tool noses.

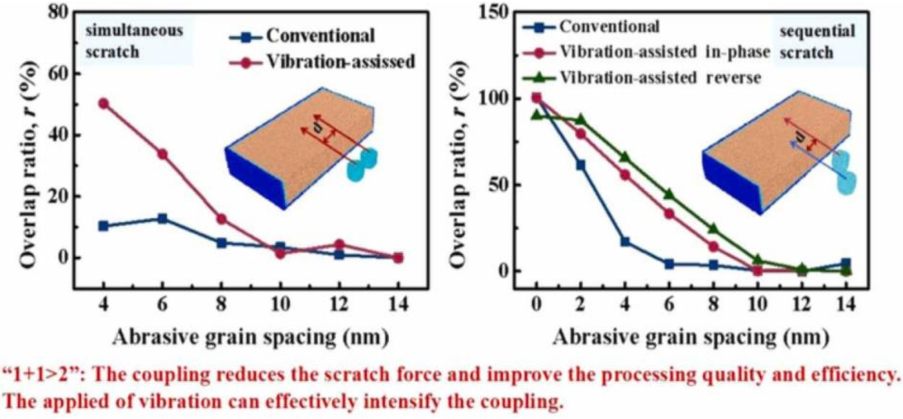
Topographic images of the micro diamond tool noses with cutting distance of 30 km.

Microstructures machined with different orientation micro diamond tools.

Figure 9 – Micro diamond tools designed with different orientation combinations [17]

The morphologies, profile errors and topological characteristic of the microstructures machined with different micro diamond tools with increasing cutting distance were analyzed. Finally, a conclusion was drawn that the wear resistances of the micro diamond tools in ascending order are $A_\gamma\{100\}A_\alpha\{100\}$, $A_\gamma\{100\}A_\alpha\{110\}$, $A_\gamma\{110\}A_\alpha\{100\}$, and $A_\gamma\{110\}A_\alpha\{110\}$. The three working areas of the $A_\gamma\{100\}A_\alpha\{100\}$ tool are prone to wear; in contrast, those of the $A_\gamma\{110\}A_\alpha\{110\}$tool are resistant to wear. The tool wear of $A_\gamma\{100\}A_\alpha\{110\}$is caused by flank face wear, and that of $A_\gamma\{110\}A_\alpha\{100\}$ is caused by rake face wear [17].

Coupling of multiple abrasive grains is crucial for the efficiency in the grinding process and grinder design. In [18] the coupling effect in a double-grain model in vibration-assisted scratch of single-crystal silicon carbide (SiC) have been investigated using the molecular dynamics simulations for both simultaneous and sequential scratch processes. The coupling between the double abrasive grains affect the scratch force, stress, amorphous layer and surface morphology. The reduction ratios of tangential and normal force and the influenced material volume show that the critical distance for the inhibition of the coupling of vibration-assisted scratch is significantly greater than that in conventional scratch (Fig. 10). The change of overlap ratio can reflect the change trend of the scratch force reduction ratio. In the vibration-assisted grinding, the increase of overlap ratio also intensifies the coupling of the abrasive grains, resulting in faster material removal, smaller scratch force and better surface finish. Insights obtained through the molecular dynamics analysis in this work into the coupling effects of abrasive grains in the vibration-assisted grinding process is believed to be beneficial in the development of grinding wheels and the optimization of machining processes.



“1+1>2”: The coupling reduces the scratch force and improve the processing quality and efficiency. The applied of vibration can effectively intensify the coupling.

Figure 10 – The coupling between the double abrasive grains affect the scratch force, stress, amorphous layer and surface morphology [19]

In article [19] Single pass scratch tests were carried out in three different grades of WC/Co, containing 6, 11, 28% of cobalt and in different environmental conditions: dry, distilled water (pH 6), acid (pH 2) and basic (pH 10) solutions in order to analyze its influence on wear and friction coefficient. Tests were conducted with increasing normal load ranging from 2 to 102 N. A drop of liquid was placed between the indenter tip and the sample at the beginning of the test. At the end of the test, sample was cleaned and dried. The total exposure time to liquid is around 200 s in order to minimize corrosion effects. Worn surfaces were analyzed by Scanning Electron Microscopy (SEM) and optical profilometry. Co% has a significant effect on mechanisms transition loads and on friction coefficient. The later increased with Co% due to the larger extent of plastic deformation. Results indicated that at loads inferior to 62 N, liquid nature does not affect friction or critical loads. However, at higher loads, liquid media effect is statistically significant and distilled water presented the lower friction coefficient and fluid wettability. The liquid acted as a lubricant resulting in lower friction when compared to dry conditions. In Rockwell tests, wear is controlled by plastic deformation, whereas, in Vickers tests, brittle-mechanisms such as cracking took place [19].

Thermally sprayed tungsten carbide coating is extensively engaged in wear resistance applications due to its good tribological properties. For some applications in aerospace, automotive, printing and forming industries, these coated components require a nanolevel surface finish. In the investigation [20], magnetorheological fluid based finishing (MRF) process is carried out on the pre-polished tungsten carbide coating using standard magnetorheological (MR) fluid which contains diamond powder as the abrasive particles. In this case, the lower gripping strength of non-magnetic abrasives into the chain structures of carbonyl iron particles (CIPs) is responsible for inadequate material removal rate (MRR) and irregular polishing. To overcome these problems, MRF is conducted with a chemical etchant and that leads to a higher finishing rate due to the integrated effect of etching and polishing. The mechanism of material removal in normal MRF operation is schematically shown in Fig. 11. In the traditional MR fluid, abrasive particles are loosely gripped in between CIPs chains under the effect of magnetic flux lines. However, the gripping force of CIP chains on abrasive particles is not sufficient to restrict the rolling motion of the abrasive particles during finishing of hard materials. Hence, a lower penetration depth is accomplished by the rolling motion of abrasives as shown in Fig. 11. Thus, material is removed by both rolling and sliding motions of the abrasive particles. Therefore, the material removal mechanism is similar to the three-body abrasive wear and that leads to an inefficient and nonuniform material removal. In addition to that, the abrasives may also be thrown away from the MR fluid ribbon at a high wheel speed due to the lack of gripping of abrasive particles into the CIP chain structures. So, it is difficult or time consuming to finish hard materials due to less abrasive particles and low forces.

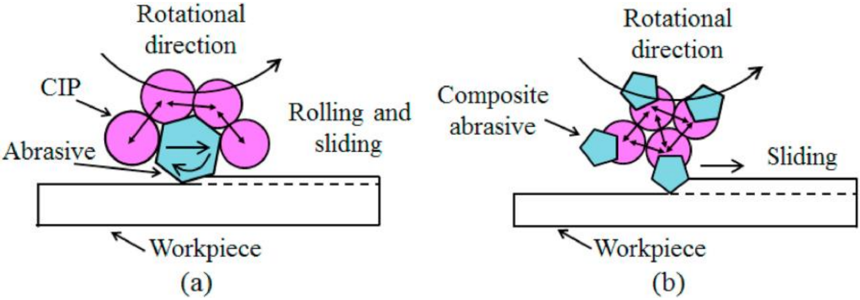


Figure 11 – Mechanism of material removal in MRF with (a) conventional MR fluid and (b) MR fluid with magnetic abrasives

As a result of presenting the available modern developments, it is possible to draw the following conclusions.

Attention is drawn to the processing of polycrystalline diamonds using the synergy of chemical and mechanical effects. Three main ways of material removal during diamond polishing are identified and summarized on the basis of experimental results: interphase mechanochemical removal, chemically stimulated mechanical removal and mechanochemical transformation of diamond. Attention is drawn to the fact that developments in the polishing of monocrystalline diamond without damage at the atomic level can be enhanced by inductively coupled plasma at atmospheric pressure.

It is shown that the accuracy of straightening diamond arc-shaped grinding wheels can be significantly increased by reducing the wear of diamond particles of the galvanic straightening tool. Graphitization appears in the ruling circle with a large grain size of diamond particles, and the wear rate of diamond particles will be accelerated. It was established that to achieve high-performance and accurate straightening of arc-shaped diamond grinding wheels, a combined method using laser rough straightening and electric discharge precision straightening is used. Moreover, the laser roughing method is used to quickly remove the excess abrasive layer to obtain an arc-shaped profile. Electroerosion precision correction not only increased the accuracy of the arc-shaped contour, but also improved the cutting ability of the grinding wheel. The use of acoustic emission intensity for the assessment of diamond wear was studied, which allows the operator to estimate the size of the worn surface and when changes are necessary to avoid burnishing of the working surface.

In order to increase the durability and self-sharpening ability of abrasive materials for efficient automated production, structured models and superhard materials have been developed and researched. In vibratory sanding, increasing the overlap ratio also increases the adhesion of the abrasive grains, resulting in faster material removal, less scratch force, and better surface finish. It is believed that the data obtained by molecular dynamics analysis on the effects of abrasive grain bonding in the vibration grinding process will be useful for the design of grinding wheels and the optimization of machining processes.

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СУЧАСНІ РОЗРОБКИ ЩОДО СПРЯМОВАНОГО ВПЛИВУ НА РІЗАЛЬНУ ПОВЕРХНЮ АЛМАЗНО-АБРАЗИВНОГО ІНСТРУМЕНТУ ТА ЙОГО КОНТАКТНУ ЗОНУ В ПРОЦЕСАХ МЕХАНІЧНОЇ ОБРОБКИ (ОГЛЯД)

Анотація. *В даній статті наведені відомості з сучасних розробок у напрямку спрямованого впливу на різальну поверхню алмазно-абразивного інструменту та його контактну зону в процесах механічної обробки. Здебільшого така обробка стикається із питаннями впливу на ріжучу поверхню алмазних інструментів, в т.ч. правлячого механічного та електрофізичного, врахуванню дефектності алмазів, якими піддається обробка, спрямованого впливу на поверхню таких алмазів, теплового та модифікуванням поверхні алмазів. Встановлено, що для досягнення високої продуктивності та точності правки алмазних шліфувальних кругів з дугоподібним профілем використовується комбінований метод лазерної чорнової правки та електророзрядної прецизійної правки. Крім того, метод лазерної чорнової обробки використовується для швидкого видалення надлишків абразивного шару для отримання дугоподібного профілю. Електроерозійна прецизійна корекція не тільки підвищила точність дугоподібного контуру, але й покращила різальну здатність шліфувального круга. Вивчено використання інтенсивності акустичної емісії для оцінки зносу алмазу, що дозволяє оператору оцінити розмір зношеної поверхні та коли необхідні зміни, щоб уникнути вигорання робочої поверхні.*

Щоб підвищити довговічність і здатність до самозаточування абразивних матеріалів для ефективного автоматизованого виробництва, були розроблені та досліджені структуровані моделі та надтверді матеріали. Під час вібраційного шліфування збільшення коефіцієнта перекриття також збільшує адгезію абразивних зерен, що призводить до швидшого видалення матеріалу, меншої сили подряпин і кращої обробки поверхні. Вважається, що дані, отримані за допомогою аналізу молекулярної динаміки про вплив зв'язки абразивних кругів у процесі вібраційного шліфування, будуть корисні для проектування шліфувальних кругів та оптимізації процесів обробки. Такі розробки дозволяють значно інтенсифікувати процеси оброблення та збільшити ефективність алмазно-абразивного інструменту. Саме тому, в даному огляді основна увага і приділена викладенню сучасних напрацювань, відомих із наукових публікацій, переважно за останні 5 років, пов'язаних із вказаними вище питаннями.

Ключові слова: *алмазно-абразивний інструмент; різальна поверхня; контактна зона; механічна обробка; дефектність алмазів; електрофізичний вплив.*