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CURRENT RESEARCH IN THE DEVELOPMENT OF TREATMENT AND POLISHING TECHNOLOGIES TO OBTAIN HIGH-QUALITY SURFACES (REVIEW)

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Abstract. *Modern research indicates the effectiveness of using abrasive and chemical-mechanical methods in polishing, taking into account the characteristics of the abrasives used. At the same time, for chemical-mechanical polishing (CMP), researchers consider two directions: the influence of different abrasives, i.e., emphasis on the mechanical component of CMP, and the influence of suspension, i.e., emphasis on the chemical component. As an abrasive for polishing, diamonds are used in the tool in the form of metallic Cu_6Sn_5 and polymer diamond film overlays, as well as with the use of a mixed abrasive suspension of cerium and diamond. The features of polishing Al_2O_3–SiO_2 with mixed particles and pure – SiO_2, as well as new abrasives of the core-shell type SiO_2@A-TiO_2 are separately considered. In new suspensions containing Fe, Al_2O_3, a new material is added - graphene oxide (GO), and deionized water is also used in CMP, and this is a certain modern research trend.*

Keywords: *surface finishing; chemical-mechanical polishing; diamond abrasives; graphene oxide; deionized water.*

1. Introduction

Previous practice of tool production and the use of cutting tools in industry has proven that to achieve effective and economical use of this modern high-value tool, it is necessary not only to ensure a high-quality polished surface, but also to have a proven cutting edge. This is the same for tools made of high-speed steels, when it is necessary to avoid unwanted burrs on the cutting edge, and for hard alloys, ceramics and superhard ceramics, when it is necessary to avoid chipping on the edge. This can only be achieved by finishing the cutting edge after grinding, and even polishing it, when the roughness of the front and rear surfaces of the tool is brought to R_a 0.05 μm, or even less, which significantly increases the wear resistance of the cutting tool and the quality of the surface processed by it.

Meanwhile, there are currently studies aimed at supposedly increasing wear resistance by changing the surfaces of the cutting tool, but the roughness of these surfaces is not paid attention at all. A striking example of such neglect is the article [1], which considers increasing the wear resistance of ground hard alloy plates by chemical treatment (passivation). At the same time, the surface roughness of the original plate was 1.3±0.2 μm in terms of R_a, and the roughness of the etched surface was 0.6–0.7 μm [1]. This leads to the conclusion that the wear resistance of the etched plate increases by 2 times. It would seem to be a new word in the processing of hard alloys. But in fact, such a study only causes surprise. If we have such roughness, it usually differs by 2 times, then the wear will also differ by 2 times. But this is not the main thing. The main thing is what kind of roughness it is. In fact, the cutting inserts RNMN 120400T (as in the article [1]) with the roughness specified above are defective, because such inserts must have a surface roughness of R_a no more than 0.20 μm and be proven. That is, the above-mentioned plates of the author [1] are defective both in the initial state and in the passivated state, and conducting these studies and drawing conclusions based on them [1] is not only incorrect, but also generally unacceptable. The importance of having proven plate surfaces, and therefore cutting edges, was pointed out 50 years ago by domestic researchers: Bakul V.M., Zakharenko I.P., Shepelev A.O., Grabchenko A.I., Matyukha P.G. and others. But over time, the practice of domestic production to a certain extent leads to simplification and a certain neglect of finishing and polishing technologies, which also affects the reduction of domestic publications. Meanwhile, foreign researchers are now paying more attention to the study of finishing and polishing technologies for mechanical engineering products.

2. The state of the art in the field of research in the field of polishing cutting tool surfaces

The surface treatment of hard alloy to the atomic level is a long-standing task in the field of manufacturing and processing of materials. To obtain high-quality products from cemented carbide with complex shapes, a new process ‘chemistry enhanced shear thickening polishing’ (C-STP) using Fenton reagent is proposed in the paper [2] to obtain polishing at a speed that is twice the speed of conventional STP. In the C-STP process, the chemical reagent in the polishing slurry, due to its high chemical affinity, diffuses to the workpiece surface and reacts with the workpiece (WC-Co). The surface material WC-Co is oxidized to a reaction layer, which is easily removed due to the simultaneous mechanical action of the grains.

Based on the results of EDS and XPS analysis, Fig. 1 shows the mechanism of material removal from tungsten carbide–cobalt alloy with Fenton suspension in the C-STP process. In the first stage, the Co element on the surface of the WC–Co alloy is first oxidized to $Co(OH)_2$ by the strong oxidant •OH, since it has a lower reaction potential than WC. Subsequently, some of the WC is oxidized to WO_3. In addition, the reaction layer formed on the upper surface is loose, which means that it is easier to remove than the WC-Co alloy. In the second stage, the $Co(OH)_2$ on the surface layer of the hard alloy is quickly removed due to the abrasive particles. In the third stage, the Co element, which is a binding phase in the hard alloy, is removed. The bonds between the hard WC phase disappear, so the WC grains and its loose oxides are relatively easily removed by abrasive particles. As a result, the fresh surface is exposed again, which can accelerate the oxidation reaction, and the synergy of both chemical and mechanical action increases the efficiency of polishing the hard alloy [2].

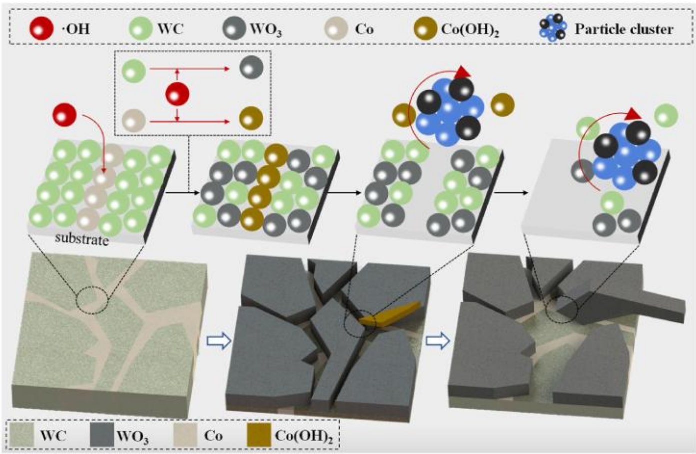
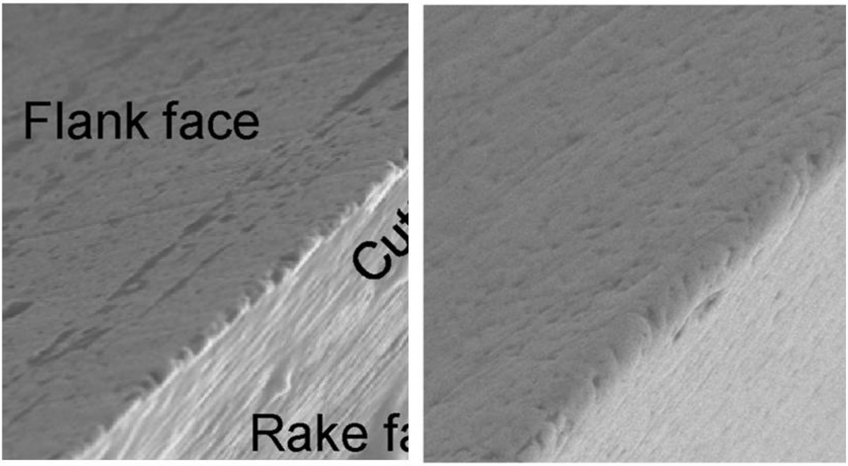


Fig. 1. Mechanism of material removal from tungsten carbide cobalt alloy by C-STP method with Fenton reagent [2].

Microdrills (Shenzhen Jinzhou Precision Technology Co., China) made of YG-6 carbide were selected to test the application of C-STP with Fenton reagent. Fig. 2(a) shows the edge shape structure of the microdrill after grinding with a diameter of 0.4 mm, with numerous defects clearly observed on the cutting edge. To solve this problem, STP and C-STP methods were used to polish the microdrill for 3 min. As shown in Fig. 2 (a), after 3 min. STP, there is still some chipping on the cutting edge and grinding marks on the front surface. The microdrill after 3 min. C-

STP (using Fenton reagent, in wt%: 0.1 H_2O_2 and 0.6 $FeSO_4$) is shown in Fig. 2 (b), where it can be seen that the cutting edge is completely smoothed and the grinding marks on the front surface are eliminated. The proposed C-STP process helped reduce the surface roughness of the carbide from the initial value of S_a 120±10 nm to 8.4±0.5 nm in less than 9 min. Elimination of microdefects on the cutting edge allows to reduce the intensity of its wear and increase the reliability and productivity of the cutting process [2].



a b

Fig. 2. Comparison of the cutting edge of a microdrill: (a) edge without polishing, (b) polishing with C-STP suspension [2].

In the paper [3], an abrasive wheel for solid-state chemical-mechanical polishing (SPCMP) and effective sharpening of the cutting edge of a carbide tool (WC–Co) was developed. Measurements by X-ray diffraction and electron backscatter diffraction showed that the SPCMP method removes hidden scratches from the surface of WC–Co materials applied by a diamond wheel. Fig. 3 shows the interaction between the cutting tool and the workpiece during the cutting process. When observed under an electron microscope, the cutting edges of commercial tools have significant irregularities, which increases the contact area with the workpiece and the cutting resistance. The unevenness of the cutting edge also affects the temperature increase during cutting, and the surface of the workpiece is subjected to increased machining deformation due to the unsatisfactory shape of the cutting edge, which further increases the unevenness of the machined surface. The method of sharpening the cutting edge proposed in this work is designed to reduce the contact area with the workpiece and the cutting resistance, and thus reduces the mechanical deformation of the machined surface. The developed grinding wheel SPCMP [3] with a diameter of 100 mm was manufactured on a phenolic binder using green silicon carbide (GC) as an abrasive component. In this study, the SPCMP grinding wheel was fabricated to avoid the transition from WC to W_2C phase during carbide machining, and to induce the oxidation of WC phase and its removal by GC. The main function of the SPCMP wheel was to obtain sharp cutting edges for carbide tools (WC–Co). When cutting with WC–Co tools with cutting edges sharpened by SPCMP, the cutting resistance was low and the wear rate was reduced. In addition, the cutting speed of WC–Co tools when cutting Ti–6Al–4V and Inconel 718 after sharpening the cutting edge with SPCMP was approximately twice that before SPCMP. It has been established that cutting heat-resistant alloys with a WC–Co tool with a sharp cutting edge leads to structural defects only near the surface, and the crystalline structure is preserved at a certain depth from the surface [3].

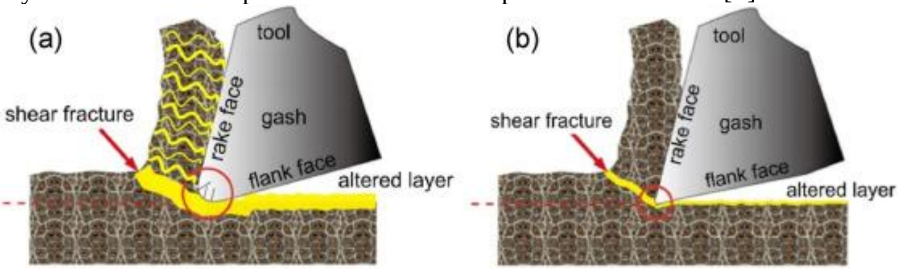


Fig. 3. Cutting with a commercial tool (a) and a tool with an edge sharpened using the technology proposed in the study [3] (b): (a) the workpiece is significantly changed by the tool during the cutting process, (b) the workpiece shows minor changes during cutting.

Bondless tungsten carbide (B-WC) is a hard and brittle ceramic material, which is mainly used for the manufacture of precision molds in the field of optics, but it is not satisfactory for precise and high-performance polishing. In the paper [4], a semi-rigid cover (SRB) tool with a radius of 40 mm is used to solve this problem. It consists of three layers. The outer and inner layers are rubber membranes with a Shore hardness of 75 HA. The middle layer is made of a 0.3 mm thick stainless steel sheet, which allows to increase the rigidity of the tool and maintain a certain flexibility. The outer rubber film is covered with a polishing pad. In [4], experiments were conducted to demonstrate the polishing and material removal characteristics of SRB on B-WC substrates. It is noted that the rough surface turned into a mirror-like surface after just 2.5 minutes of polishing. And the surface roughness in Sa was reduced from 104 nm on average to 3.7 nm. In addition, deep grinding tool marks were effectively removed, leaving only nanometer scratches from the polishing abrasive. The results indicate that SRB is effective for rapid polishing of B-WC with good surface and subsurface quality.

The above indicates that foreign researchers pay due attention to the polishing of hard alloys and a high-quality cutting edge. At the same time, they consider the processes of chemical-mechanical [2, 3] and abrasive polishing [4]. At the same time, we will also pay attention to modern work on polishing with the use of cerium oxide, which is aimed exclusively at physical influence. Here, polishing, according to the author [5], occurs without physical contact of the lapping compound and the processed material. The removal of the processed material, the wear of cerium oxide particles and the lapping surface is a consequence of the Förster resonant energy transfer between them, which occurs in the processed surface–polishing powder–lapping surface system due to excitonic transitions between the energy levels of donor-acceptor pairs in an open microresonator [5]. That is, it is not a direct mechanical impact that is used here, but a resonant action in a microresonator between the processed material and the lapping. Such physical non-contact polishing raises more questions than answers, but in this case, we will pay attention to the fact that the most common polishing methods are divided by type of action only into: mechanical (abrasive) and chemical-mechanical, which we will consider further in a review of the most modern works of foreign researchers.

3. Formulation of the purpose of the research

The above studies indicate the effectiveness of the use of abrasive and chemical-mechanical methods in polishing and taking into account the characteristics of the abrasives used, therefore the purpose of this article was to investigate the latest (2024–2025) developments in technologies for finishing and polishing surfaces of a wide range of modern materials and to identify areas for increasing the effectiveness of such developments.

4. Presenting main material

Let us first consider developments in abrasive finishing and polishing of surfaces of various ceramic materials.

In [6], a new strategy for using the intermetallic compound Cu_6Sn_5 as a bond in a diamond grinding wheel for grinding and finishing SiC wafers with high service life and low damage processing is proposed. A ball mill for Cu_6Sn_5 powder is used to effectively reduce the particle size, increase the oxygen content and realize the surface ceramization of the intermetallic powder. After 26 hours of ball milling, the average diameter of Cu_6Sn_5 powder decreased from 7.673 μm to 0.777 μm, and the oxygen content increased from 0.2503 to 1.613% compared to the original powder. The brittleness of the sintered Cu_6Sn_5 block increases due to the formation of Sn–O chemical bonds on the surface of the powder. The use of ball milled Cu_6Sn_5 powder as a binder for preparing diamond grinding wheels for grinding SiC wafers allowed achieving good grinding performance (Fig. 4). The maximum current of the grinding machine, wear coefficient, SiC wafer roughness and damaged layer thickness were 5.9 A, 0.22, 1.519 nm and 0.76 μm, respectively. This new strategy of using a surface-ceramic intermetallic compound as a grinding wheel bond is important for the development of a high-performance technology for grinding and finishing SiC wafers [6].

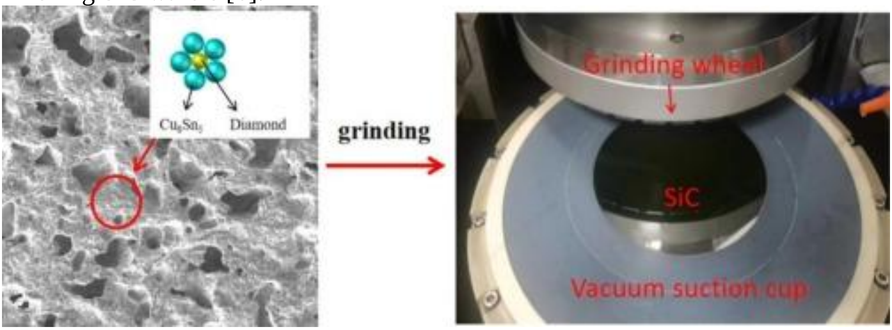


Fig. 4. Application of the intermetallic compound Cu_6Sn_5 as a bond in a diamond grinding wheel for grinding and finishing SiC plates [6].

The study [7] examined the material removal rate (MRR) for machining single-crystal SiC substrates using a fixed abrasive pad of agglomerated diamond (AD) (FADAP). At the same time, the MRR of the CMP process of a single-crystal SiC substrate reached 36.26 μm/h at a polishing pressure of 27.6 kPa and a size range of the initial AD abrasive particles of 7–10 μm. That is, the possibility of effective processing of single-crystal SiC substrates using FADAP was confirmed.

Cylindrical rollers made of Si_3N_4 ceramics serve as rolling elements of precision bearings. These rollers are especially advantageous for equipment operating under heavy loads and at high speeds. The quality of the outer surface of these rollers significantly affects both the accuracy of movement and the service life of the bearing. Considering the high hardness and brittleness of Si_3N_4 ceramics, the processing of this material is quite problematic. In the study [8], a new method of double-sided grinding using diamond film pads (DFP) for processing cylindrical Si_3N_4 rollers is presented. The results show that the maximum achievable MRR is

1.237 μm/min. The abrasive size has the greatest impact on the MRR, followed by the loading pressure and the speed ratio. Reducing the abrasive size correlates with a lower average surface roughness R_a, while using larger abrasives with a higher loading pressure and a speed ratio of 1 can reduce the R_a value. For finer abrasives, reducing the loading pressure and reducing the processing time can improve the surface roughness R_a. In this study, defect-free surfaces of ceramic cylindrical rollers with a minimum average roughness of 6 nm and a deviation of 2 nm were obtained. In addition, this process using DFP only requires the addition of deionized water, making it environmentally friendly. The principles and device of double-sided grinding using DFP for cylindrical rollers are shown in Fig. 5. Before the grinding process begins, the DFP is securely attached to both the upper and lower plates. During grinding, the spindle ensures simultaneous rotation of both the upper and lower plates, applying a constant load pressure to the workpiece. At the same time, the workpiece is rotated by the conductor, while deionized water is continuously injected as a working fluid into the grinding zone. As a result, material is removed from the workpiece surface through the abrasive action provided by film gaskets attached to the upper and lower plates [8].

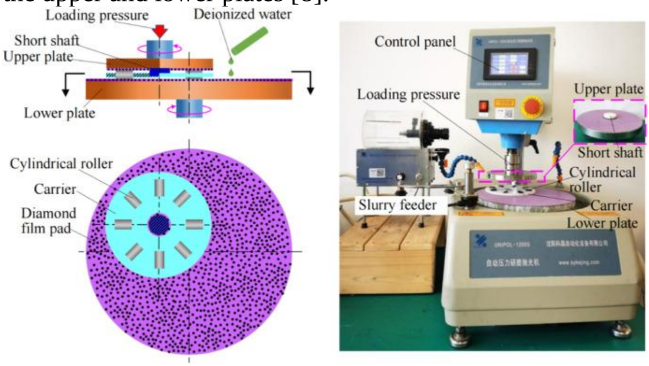


Fig. 5. Grinding principle and equipment used for double-sided grinding using DFP [8].

As we have shown above in Section 2, CMP is currently the most widely used method of material removal and surface leveling. Researchers are considering two directions: the effect of various abrasives, i.e., the emphasis on the mechanical component of CMP [9–11], and the effect of suspensions [12–18], i.e., the emphasis on the chemical component.

In the study [9], an environmentally friendly method for improving the performance of glass polishing using a mixed abrasive suspension of cerium and diamond was proposed. The addition of diamond abrasive improved the polishing properties of the cerium-based abrasive. Polishing experiments showed that compared to a single cerium abrasive, the material removal rate (MRR) of the mixed abrasive slurry increased from 82.7 nm/min to 109.6 nm/min, while the surface roughness (Ra) decreased from 26.4 nm to 0.6 nm after polishing.

It is usually believed that abrasive particles play a role only in “mechanical wear” in CMP, neglecting their influence on chemical reactions. The study [10] reveals the chemical role of Al_2O_3 particles in ruthenium CMP by comparing the properties and polishing performance of Al_2O_3–SiO_2 mixed particles and pure SiO_2 (Fig. 6). The results show that Al_2O_3 particles enhance the mechanical impact by reducing the Zeta potential and promote the chemical action by catalyzing hydrogen peroxide to produce hydroxyl radical (Fenton-type reaction) on the Ru surface. They increase the MRR of ruthenium (Ru) in CMP with mixed abrasive particles by almost 5 times, and the surface roughness is reduced by 60%. The chemical reaction mechanism stimulated by the increase in the concentration of hydroxyl radicals on the Ru surface is confirmed by the increase in the corrosion current, the thickness of the oxide layer, and the fraction of high-valent RuO in the oxide layer. Among them, the thickened oxide layer is a significant factor contributing to the significant increase in the MRR of Ru and the decrease in the surface roughness.

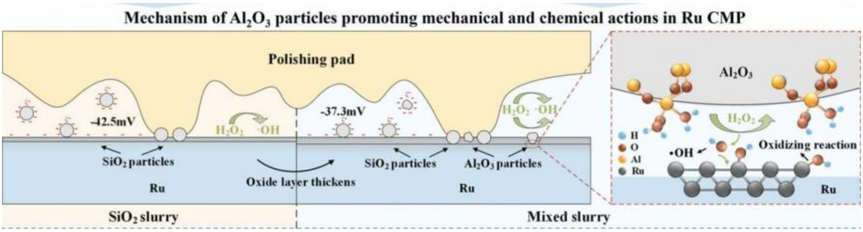


Fig. 6. Mechanism of influence of Al_2O_3 particles on mechanical and chemical effects during CMP of ruthenium [10].

It is extremely difficult to obtain an atomic surface on fused silica with a high MRR. In addition, toxic and corrosive suspensions are widely used in traditional CMP. To solve these problems, core-shell SiO_2@A-TiO_2 abrasives were fabricated and a new photocatalytic CMP was developed [11]. The developed suspension consists of sodium carbonate, hydrogen peroxide, sodium carboxymethyl cellulose and deionized water. After CMP, an atomic surface with a surface roughness Sa of 0.181 nm was obtained at a scanning area of 50×50 μm^2 and a high MRR of 10.727 μm/h. The developed SiO_2@A-TiO_2 abrasives can generate electrons and holes when irradiated with simulated sunlight, producing free radicals

(OH–) (Fig. 7). As a result, OH– combine with Si atoms on the surface of fused quartz, forming Si-OH-Si bonds. This engineered relationship between the suspension and the fused quartz surface through SiO_2@A-TiO_2 abrasives improves the synergistic effect between chemical and mechanical functions. The prepared SiO_2@A-TiO_2 abrasives with core-shell structure were applied to develop a new suspension for realizing highly efficient photocatalytic chemical-mechanical polishing of fused quartz under artificial sunlight irradiation.

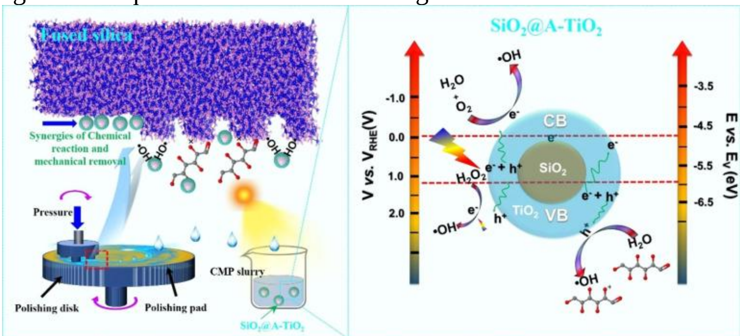


Fig. 7. Mechanism of influence of SiO_2@A-TiO_2 abrasives on mechanical and chemical actions in CMP [11].

In [12], a new approach using colloidal silica and organic salt additives for ultra-precision processing of GaN films was presented. The chemical-mechanical polishing process significantly reduced the surface roughness (S_q) to a minimum of 0.63 nm, while simultaneously increasing the material removal rate by 60 % (from 70 nm/h to 112 nm/h). Contact angle experiments confirmed the increased wettability of the slurry due to organic salts, when the contact angle between the polishing slurry and the GaN surface decreases from 20° to an angle of less than 10°.

Increasing the interfacial reactivity of the polishing slurry is crucial for improving the polishing efficiency and surface quality of sapphire wafers. In the study [13], a new green polishing slurry was developed containing aminomethylpropanol, xylitol, highly active silica, and deionized water. Experiments showed that the new green polishing slurry reduced the surface roughness by 12.5 % and increased the material removal rate by 71.3 % compared to the traditional polishing slurry. The results showed that aminomethylpropanol promotes chemical reactions between the green polishing slurry and the sapphire wafers, leading to the conversion of the intermediate product $Al(OH)_3$ to $Al(OH)_{4-}$. In addition to the complexation reaction between xylitol and $Al(OH)_{4-}$, it was found that ions accelerate the removal of surface materials from sapphire plates during polishing, which leads to increased polishing efficiency and surface quality.

Planarization of silicon carbide (SiC) by CMP is a serious problem. In [14], the CMP performance of a new suspension containing Fe, Al_2O_3 and graphene oxide (GO) was investigated. Morphological characterization revealed a significant increase in Fe dispersion due to the presence of GO, as the latter, as an excellent support material, can significantly improve the catalytic performance. In addition, CMP results showed that the material removal rate (MMR) using the new slurry can reach 700 nm/h, which leads to a decrease in the average surface roughness (Sa) to 0.6175 nm. By varying the concentration of hydroxyl radical (•OH), it was found that the new slurry generates sufficient amount of •OH to oxidize the SiC surface.

The above referred to the polishing of ceramic materials, but researchers also pay due attention to the processing of metal materials.

Titanium alloy TC4 has become one of the important materials for aerospace and medical device applications due to its advantages such as good biocompatibility and high specific strength. However, the high hardness and low thermal conductivity of TC4 make it difficult to process. Therefore, a new suspension consisting of SiO_2, H_2O_2 and 2-ANA was developed for CMP of TC4 [15]. The results show that the suspension containing 2-aminobenzoic acid (2-ANA) as a chelating agent exhibits the best polishing characteristics with an R_a of 0.661 nm and a material removal rate of 173.9 nm/min. The complexing agent 2-aminobenzoic acid promotes the formation and dissolution of the oxide film. Based on the characteristics of XPS and infrared study, the following mechanism of CMP TC4 was revealed: hydrogen peroxide oxidizes the Ti element into high-valent oxides, the −N–H and −O–H groups in 2-ANA combine with metal ions in solution to form complexes, and this chemical process reaches a dynamic equilibrium with the mechanical action of abrasive grains, which ultimately provides super-smooth polishing of TC4 (Fig. 8).

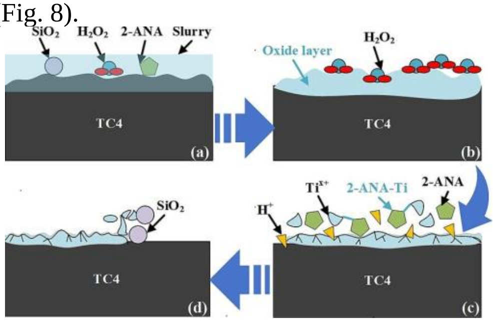


Fig. 8. Mechanism of CMP of titanium alloy TiC4 [15].

Cobalt-chromium-molybdenum (CoCrMo) alloy is characterized by good wear resistance, high corrosion resistance and excellent biocompatibility. However, high-performance devices with CoCrMo require the surface roughness R_a to be less than 1 nm, which makes ultra-precision machining difficult. To solve this problem, a new environmentally friendly CMP method containing silicon oxide, hydrogen peroxide, tartaric acid and deionized water has been developed [16]. After CMP, a surface roughness of R_a 0.16 nm is achieved for the CoCrMo alloy. X-ray, photoelectron and infrared spectroscopy showed that hydrogen peroxide dominates the oxidation processes in CMP. Co-oxides were softened and dissolved by hydrogen ions. Cr and Mo oxides showed relatively better stability and less dissolution in tartaric acid, which avoids excessive corrosion. Other oxides are removed by silica. The released metal ions are chelated by tartaric acid during the polishing process (Fig. 9).

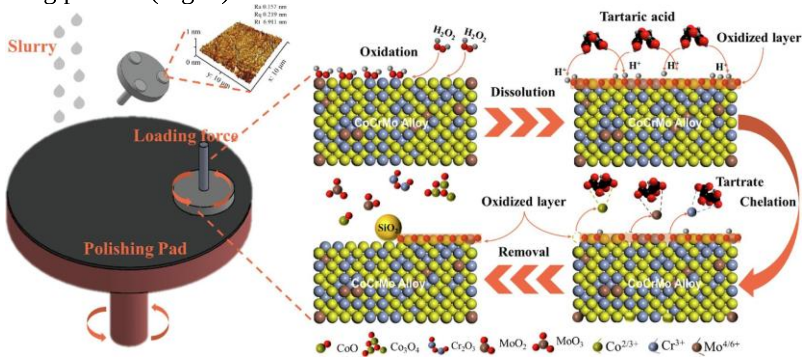


Fig. 9. CMP mechanism Cobalt-chromium-molybdenum alloy [16].

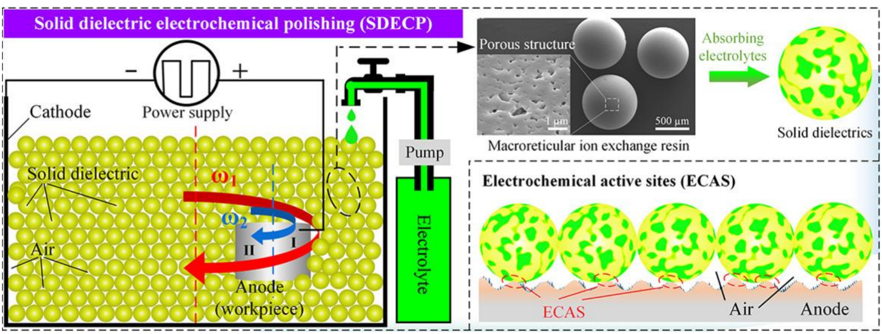


Fig. 10. Mechanism of solid dielectric electrochemical polishing (SDECP) [17].

Surface post-processing of metal additive manufacturing components is a challenging task due to their typically complex geometry (e.g., curved surfaces) combined with high initial surface roughness. In the article [17], an effective method of solid dielectric electrochemical polishing (SDECP) is proposed, which uses ion exchange resin particles with a porous structure that absorbs and stores electrolytes as a conductive medium (Fig. 10). This method improves the surface quality of additively manufactured components with Bezier curved surfaces to a specular gloss, achieving improvements in S_a, S_q, and S_z of 91.5 %, 91.7 %, and 86.9 %, respectively. The results show that the bidirectional planetary motion in SDECP effectively improves the uniformity of surface roughness and material removal in different regions of the part.

The study [18] used macroscopic CMP and microscopic atomic force microscopy to investigate the mechanism of microscratching on copper during CMP from the perspective of abrasive particles. In a near-neutral suspension containing low concentrations of H_2O_2, copper can be oxidized to cupric oxide and/or cuprous oxide, forming a brittle oxide layer that can be removed by abrasive silica particles. The removed copper oxides can adhere to the abrasive silica particles by electrostatic attraction, changing the surface state (Fig. 11). The adhered copper oxides have irregularities and high hardness, which probably causes high local contact stresses and leads to micro-scratches on the copper surface being polished. Therefore, the study showed that the adhesion of copper oxides to silica particles should be avoided.

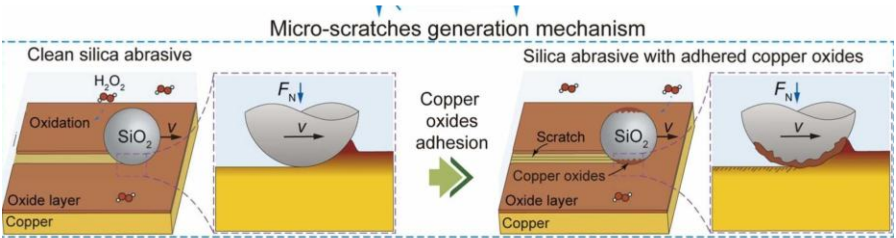


Fig. 11. Modeling the formation of scratches on the copper surface during polishing [18].

Ultra-precision surfaces of rotation are crucial for mechanical components such as bearings, but they are difficult to achieve by conventional machining. Meanwhile, it is difficult to predict the evolution law of surface roughness during machining. In the study [19], a super-precision chemical mechanical polishing (CMP) method was proposed for machining surfaces of rotation. A theoretical model of surface roughness R_a was created, assuming that the three-dimensional surface morphology can be simplified to two-dimensional identical triangles, each peak can be removed uniformly, and the removal of material in the depressions can be neglected compared to the removal of material at the peaks (Fig. 12). The model provides an intuitive understanding of the evolution law of R_a during CMP. Interestingly, R_a initially decreases parabolically, which is determined by the initial surface roughness R_{a0}, the material removal rate MRR_V, and the polishing time t. It then stabilizes. The cylindrical guide surface of the bearing was polished using the developed CMP method. In 6 min R_a can be significantly reduced from the initial 201.09 nm to 1.50 nm almost parabolically and stabilizes. The experimental results mostly confirm the theoretical model of R_a, except that the slow reduction stage appears in the intermediate stage, since the real surface cannot be perfectly uniform. In addition, the roundness error RONt is reduced by 34 %.

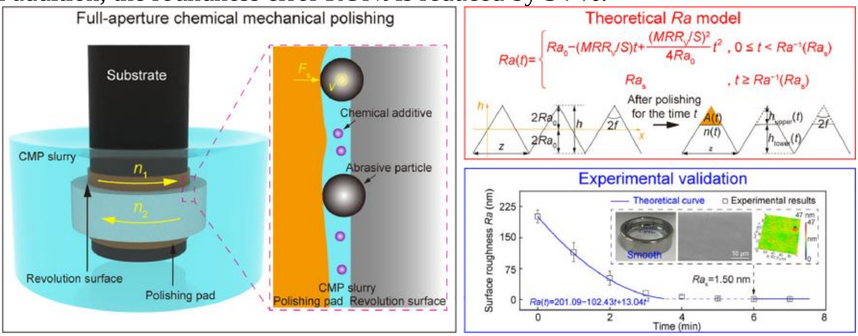


Fig. 12. CMP mechanism and theoretical model of surface roughness [19].

5. Conclusions

Thus, it is possible to draw the following conclusions from the above.

1. Modern studies indicate the effectiveness of using abrasive [6–9] and chemical-mechanical [10–18] methods in polishing, taking into account the characteristics of the abrasives used. For CMP, researchers consider two directions: the influence of different abrasives, i.e., emphasis on the mechanical component of CMP [9–11], and the influence of suspension [12–18], i.e., emphasis on the chemical component.

2. Research into the priority of the abrasive component is presented in [6] by a new strategy of using the intermetallic compound Cu_6Sn_5 as a bond in a diamond grinding wheel for grinding and finishing SiC plates with high service life and low damage processing. In the study [8], a new method of double-sided grinding using diamond film pads (DFP) for processing cylindrical Si_3N_4 rollers is presented.

In the article [9], an environmentally friendly method for improving polishing performance using a mixed abrasive suspension of cerium and diamond is proposed.

3. The study [10], as a transition from mechanical to chemical component, reveals the chemical role of abrasive Al_2O_3 particles in ruthenium CMP by comparing the properties and performance of polishing Al_2O_3–SiO_2 mixed particles and pure SiO_2. In work [11], core-shell SiO_2@A-TiO_2 abrasives were prepared in a new suspension for the implementation of highly efficient photocatalytic chemical-mechanical polishing under irradiation with artificial sunlight.

4. We will pay special attention to the use of deionized water in CMP, as this is a certain modern research trend [8, 11, 13, 18].

5. In [14], the characteristics of CMP were investigated with a new suspension containing Fe, Al_2O_3 and a new material – graphene oxide (GO), since the latter is an excellent carrier material, the characteristics of which can significantly improve the catalytic characteristics of the suspension.

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СУЧАСНІ ДОСЛІДЖЕННЯ В РОЗРОБЦІ ТЕХНОЛОГІЙ ДОВЕДЕННЯ ТА ПОЛІРУВАННЯ ДЛЯ ОДЕРЖАННЯ ВИСОКОЯКІСНИХ ПОВЕРХОНЬ (ОГЛЯД)

Анотація. *Попередньою практикою інструментального виробництва та застосування різального інструменту у промисловості доведено, що для досягнення ефективного та економного використання цього сучасного високовартісного інструменту треба не тільки забезпечити високоякісну шліфовану їх поверхню, але і мати доведену різальну крайку. Досягнути* *цього можливо лише доведенням після шліфування різальної крайки, а і навіть її поліруванням, коли шорсткість передньої та задньої поверхонь інструменту доводиться до R_a 0,05 мкм, а іноді навіть менше, що значно підвищує зносостійкість різального інструменту та якість обробленої ним поверхні. Сучасні дослідження свідчать про ефективність застосування при поліруванні абразивних і хіміко-механічних методів та врахуванні при цьому особливостей абразивів, які застосовуються, тому метою даної статті було дослідити найновіші (2024–2025 рр.) розробки в технологіях доведення та полірування поверхонь широкої гами сучасних матеріалів та визначити напрямки підвищення ефективності таких розробок. При цьому для хіміко-механічного полірування (CMP) дослідниками розглядається два напрямки: вплив різного абразиву, тобто наголос на механічний складовій CMP, та вплив суспензії, тобто наголос на хімічній складовій. Дослідження в напрямку пріоритетності абразивної складової представлені новою стратегією застосування інтерметалічної сполуки Cu_6Sn_5 у якості зв'язки в алмазному шліфувальному крузі для шліфування і доведення пластин SiC з високим терміном служби і обробки з низьким рівнем пошкоджень. Досліджено новий метод двостороннього шліфування із застосуванням алмазних плівкових накладок для обробки циліндричних роликів Si_3N_4. Запропонований екологічно чистий метод поліпшення продуктивності поліровки із застосуванням змішаної абразивної суспензії церію і алмаза. Дослідження , як перехідне від механічної до хімічної складової, розкриває хімічну роль абразивної Al_2O_3–частинки при CMP рутенію шляхом порівняння властивостей і продуктивності поліровки Al_2O_3–SiO_2 змішаними частинками і чистими – SiO_2. Представлені нові розробки з виготовлення абразивів типу ядро-оболонка SiO_2@A-TiO_2 в новій суспензії для реалізації високоефективної фотокаталітичної хіміко-механічної поліровки при опроміненні штучним сонячним світлом. Досліджені характеристики CMP за нової суспензії, що містила Fe, Al_2O_3 і новітній матеріал – оксид графена, оскільки останній є чудовим матеріалом-носієм, характеристики якого можуть значно поліпшити каталітичні характеристики суспензії. Окремо звернено увагу на застосування при CMP деіонізованої води, оскільки це є певним сучасним трендом досліджень.*

Ключові слова: *доведення поверхні; хіміко-механічне полірування; алмазні абразиви; оксид графена; деіонізована вода.*