# New PVD-Coated Carbide Grade AC1030U for Precision Turning

Takato YAMANISHI*, Hiroki TAKESHITA, Shinya IMAMURA, Kazuhiro HIROSE and Haruyo FUKUI

In recent years, automotive components have become smaller and lighter due to the trend of energy saving and fuel efficiency. Accordingly, a wider variety of materials, including those difficult to cut, have been used for these components. Sumitomo Electric Hardmetal Corporation has developed the new coated carbide grade "AC1030U" by applying the new physical vapor deposition (PVD) coating technology "Absotech Bronze" and the new chip breaker "FYS type" that has excellent chip control and high wear resistance in fine finishing. AC1030U with high cutting edge quality and high wear resistance is a general grade used for precision turning. The new grade and chip breaker can satisfy the demand for cost reduction in precision machining for various materials such as alloy steels, carbon steels, stainless steels, heat-resistance steels, and pure iron.

Keywords: cutting tool, coated carbide, PVD

## 1. Introduction

Among the indexable insert grades used for cutting tools, those with hard ceramics coated over a cemented carbide substrate (hereinafter referred to as coated grades) are increasingly being used. They now account for more than 70% of all indexable insert grades because of their good balance between wear resistance and fracture resistance compared to other tool grades.(1)

Work materials that are machined using coated grades include various steel materials, such as carbon steel, alloy steel, stainless steel, and cast iron. In recent years, the competition for energy saving and fuel efficiency has been increasingly intensified, particularly in the automotive industry. The automotive components have therefore become smaller and lighter, whereas work materials have become more diversified.

Consequently, high performances are required for cutting tools, particularly for those used in precision machining of small components. These cutting tools should be versatile, capable of cutting a wide range of work materials such as steel, stainless steel, heat-resistive steel, and pure iron, and have a good finishing performance to meet the requirements of finished surface precision. The conventional cutting tools hardly satisfy these requirements, and they need frequent replacement because tools need to be changed depending on the materials to be machined. Moreover, their life is short, which eventually causes a decrease in productivity.

To address these issues, we have developed AC1030U, a physical vapor deposition (PVD)*1 coated grade for precision machining, by applying the new PVD-coating technology "Absotech Bronze." We have also added to our lineup the FYS-type grinded chip breaker for fine finishing. The background of their development and their performance, with examples of applications, are described in the following sections.

## 2. Issues of Precision Machining of Small Components

According to the survey, more than 70% of the factors that determine tool life in precision machining of small components are related to finished surface appearance and accuracy problems, such as a clouded finished surface and insufficiently smooth surface, as shown in Fig. 1.

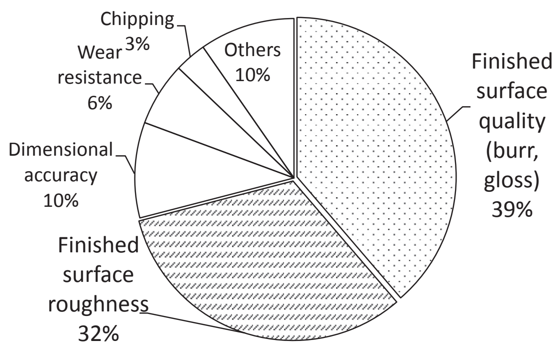



Fig. 1. Factors for tool life in precision machining of small components

Figure 2 shows the relationship between damage to the tool and finished surface quality. The damage to the tool that is particularly related to finished surface quality occurs where the tool directly contacts the work material, which is indicated as "nose R" and "front notch" in the figure. In general, the progress of wear or the occurrence of abnormal damage at this nose R and front notch part, such as chipping and deposit, has an adverse effect on finished surface quality. The resulting blemished surface or worsened surface roughness often indicates the end of the tool life.

However, an enhanced finished surface quality is required in precision machining of small components. Shown in Fig. 3 are examples of indexable inserts for

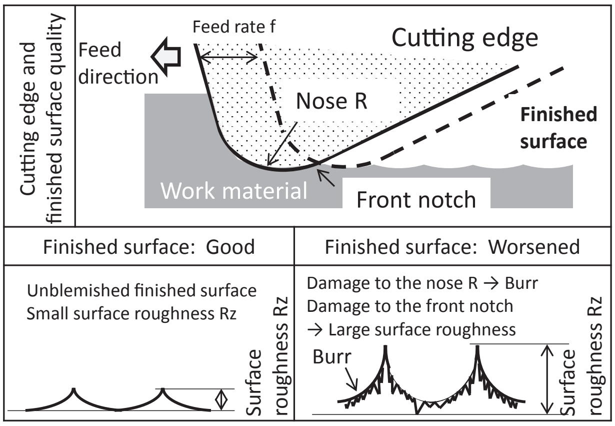



Fig. 2. Relationship between damage to the tool and finished surface quality

precision machining and the relationship between cutting edge quality and finished surface quality. Cutting edge quality may be affected by the existence of a minute chipping of a coating film at the nose R part or undulation in the cutting edge at the front notch part, prior to the use of the tool. These conditions can prevent the tool from satisfying the required standard for finished surface quality, even at the initial stage of machining, or otherwise its life will be shortened.

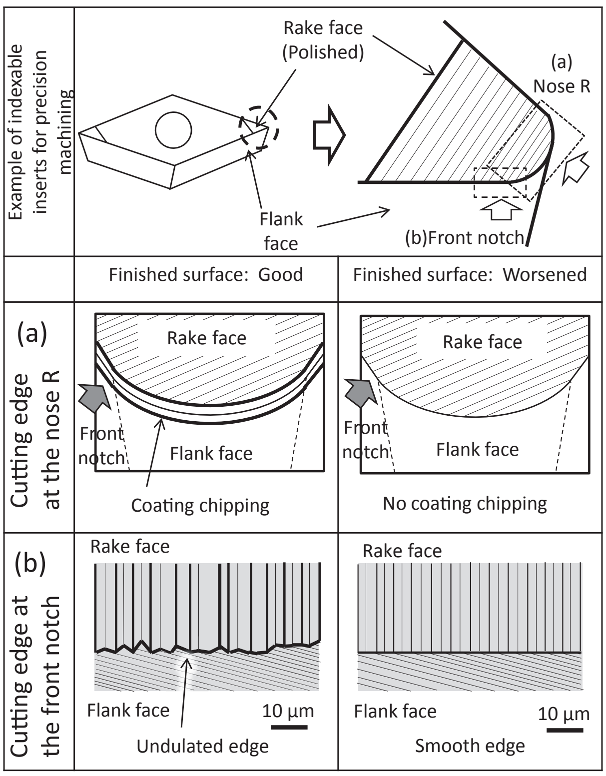



Fig. 3. Relationship between cutting edge quality and finished surface quality

## 3. Development of and New Technology for AC1030U

Figure 4 shows our lineup of PVD-coated grades for precision to finish machining. The span from low-speed precision machining to high-speed finish machining is covered by conventional grades (ACZ150, AC520U, AC6040M) and by the newly developed AC1030U. ACZ150 covers the low-speed range in precision machining, AC520U comprises the high-speed range in precision to finish machining, while AC6040M is particularly applied in the rough to finish machining of stainless steel. The new AC1030U is a PVD-coated grade covering a wide range in precision machining, from low- to medium-speed.

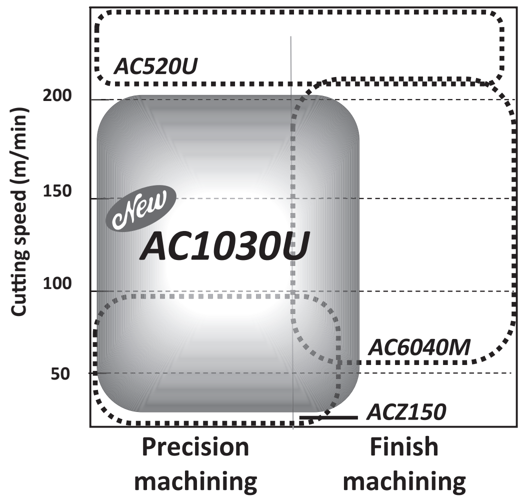



Fig. 4. AC1030U application range

### 3-1 Development target of AC1030U

In order to define the development target for AC1030U, an analysis was performed on the damage to used inserts of conventional PVD grades at their actual precision machining site. It was determined that, even though conventional grades were excellent both in wear resistance and in performance against the worsening of finished surface quality caused by the progress in wear, they were likely to worsen the finished surface quality at the initial stage of machining.

Consequently, the development targets for AC1030U included a wear resistance equivalent to or better than that of conventional grades used for machining the typical work materials in small automotive components, such as alloy steel, stainless steel, heat-resistive steel, and pure iron. Furthermore, AC1030U should provide the best finished surface quality at the initial stage of machining among all indexable insert grades used for precision machining that are available in the market. Thus, efforts were made to improve the tool cutting edge quality, which significantly affects the finished surface quality at the initial stage.

### 3-2 Development of AC1030U

AC1030U uses a dedicated cemented carbide substrate and employs our original PVD coating technology Absotech Bronze. Figure 5 shows the structure of AC1030U. The PVD coating makes use of our originally developed high adhesion technology, excellent in peeling resistance. It also adopts not only an ultra-multilayer thin coating structure, excellent in wear resistance, but also a smooth layer at the top surface to suppress chipping of the cutting edge coating, which significantly affects the finished surface quality. As shown in Fig. 6, this new coating has solved the coating-chipping problem seen in conventional grades.

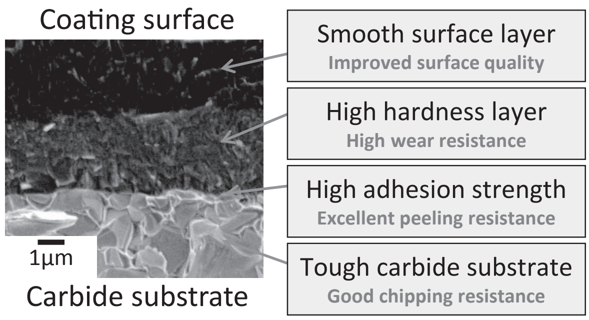



Fig. 5. Structure of AC1030U

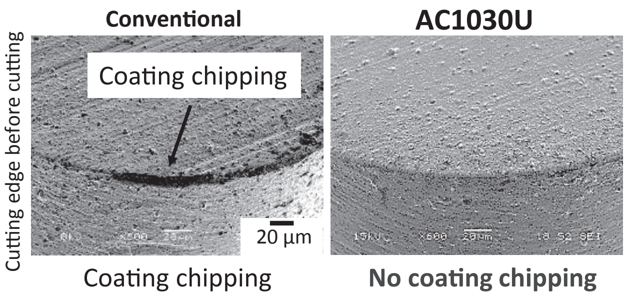



Fig. 6. Cutting edge quality of AC1030U

In precision machining, the edge shape of an indexable insert is strongly affected by grinding. Therefore, compared with the conventional grade, the cutting edge surface roughness of AC1030U has been significantly improved with the new polishing technology, as shown in Fig. 7.

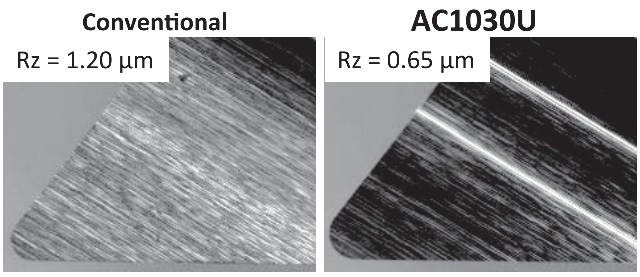



Fig. 7. Polished cutting edge of AC1030U (uncoated)

As shown in Fig. 8, this polishing quality improvement, in combination with the new PVD coating, prevented cutting edge undulation, and significantly improved the cutting edge quality.

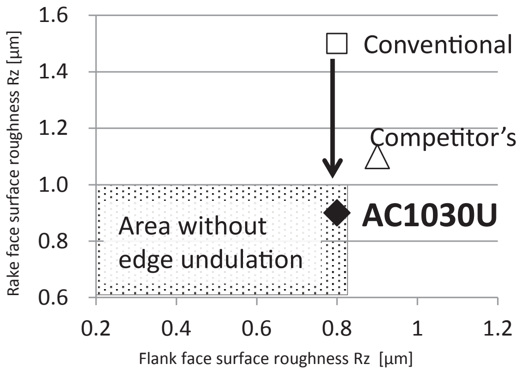



Fig. 8. Correlation between cutting edge surface roughness and edge undulation (coated)

### 3-3 Cutting performance of AC1030U

Figures 9 to 11 show the cutting performance of AC1030U by work material.

Shown in Fig. 9 is the performance of AC1030U in cutting alloy steel. It indicates that, with the improved cutting edge, AC1030U has achieved a fine finished surface compared with the conventional and competitor's grades.

Figure 10 shows the performance in machining stainless steel. It also points out that, with less wear volume, AC1030U has achieved a better finished surface roughness from the initial stage than the conventional and competitor's grades.

Figure 11 shows the performance in processing heat-resistive steel. It indicates that, with less wear on the cutting face side, AC1030U has achieved a better finished surface compared with the conventional and competitor's grades.

Regarding cutting performance for each work material, the cutting edge quality improvement obtained by the

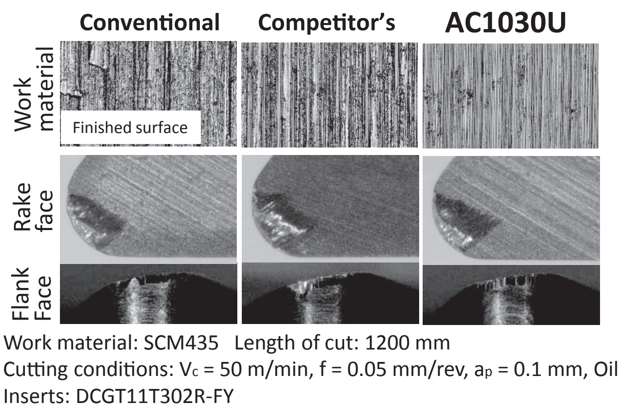
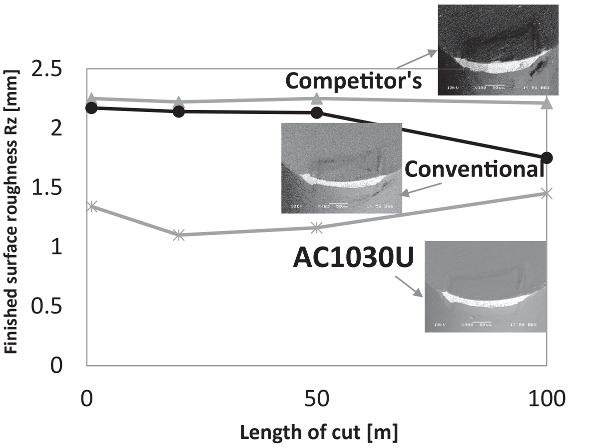
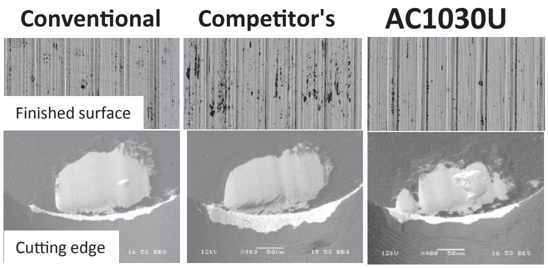



Fig. 9. Cutting performance of AC1030U (Alloy steel)




Work material: SUS304 *Photos show length of cut = 100 m
Cutting conditions: $V_c$ = 100 m/min, f = 0.05 mm/rev, $a_p$ = 0.1 mm, Oil
Inserts: DCGT11T302R-FY

Fig. 10. Cutting performance of AC1030U (Stainless steel)




Work material: SUH310 Length of cut: 1200 mm
Cutting conditions: $V_c$ = 100 m/min, f = 0.05 mm/rev, $a_p$ = 0.1 mm, Oil
Inserts: DCGT11T302R-FY

Fig. 11. Cutting performance of AC1030U (Heat-resistive steel)

new PVD coating and polishing technology has exerted the intended effect, and AC1030U has achieved wear resistance and finished surface quality equivalent to or even better than the conventional and competitor's grades.

## 4. FYS Chip Breakers for Fine Finishing

In precision machining of small components made of low-carbon steel, pure iron, or other soft materials that are likely to adhere to the tool, chip control and material type determine the tool life and productivity. Our lineup of grinded chip breakers for precision machining includes the FY and FX types (for low-depth cut and low-speed feed), the W and SD types (for relatively near-finish machining), and the wiper-shaped SDW type, and currently the FYS type has been developed for fine finishing.

With a breaker width narrower than that of the existing chip breakers, the FYS chip breaker has an improved chip control performance, particularly for fine finishing with a feed distance of less than 0.05 mm/rev. and a depth of cut of less than 1.0 mm. Shown in Fig. 12 is the recommended use range of our grinded chip breakers. With the FYS chip breaker added to the lineup, a wide range of machining is covered from fine to finish machining.

In addition, as shown in Fig. 13, the improved chip control of the FYS chip breaker suppresses wear on the cutting face in pure iron machining, thereby allowing for a longer tool life in fine finishing.

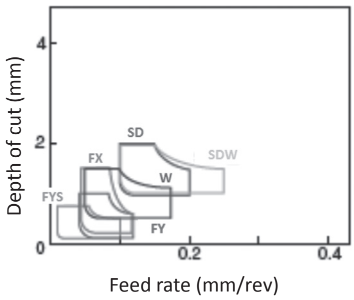
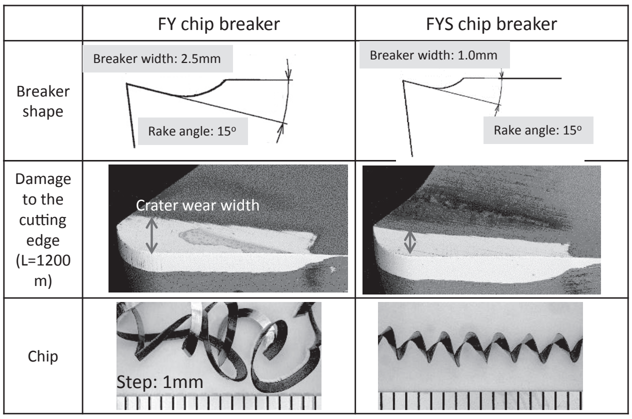



Fig. 12. Recommended range for grinded chip breakers




Work material: Pure iron
Cutting conditions: $V_c$ = 120 m/min, f = 0.02 mm/rev, $a_p$ = 0.8 mm, Oil
Inserts: DCGT11T302R-FY,FYS

Fig. 13. Cutting performance of FYS chip breaker

## 5. Application Examples of AC1030U

Figures 14 to 16 show examples of the AC1030U being used at actual production sites.

Shown in Fig. 14 is an actual example of steel machining with AC1030U. Even after twice as many pieces machined as by the conventional grade, AC1030U could still machine work materials with a stable surface quality, without any abnormal damage such as cutting edge chipping.

Figure 15 shows an actual example of AC1030U for stainless steel machining. Similarly, even after twice as many pieces machined as by the competitor's grade, the work materials could be stably machined without any abnormal damage such as cutting edge chipping.

Figure 16 shows an actual example for pure iron machining. Even after 1.5 times as many pieces machined as by the conventional grade, the state of damage was stable without, for example, cutting edge chipping.

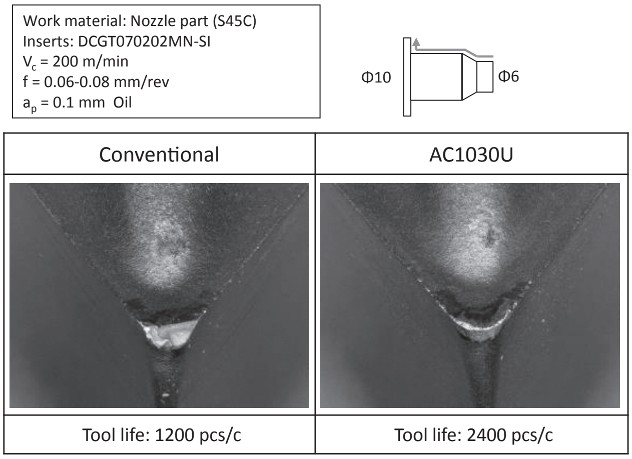



Fig. 14. Application example of AC1030U (Steel machining)

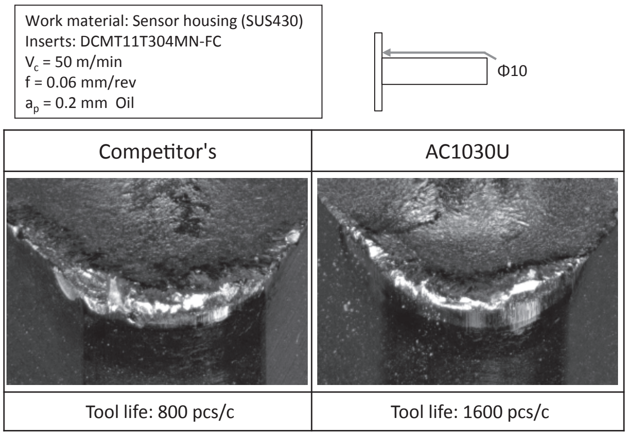



Fig. 15. Application example of AC1030U (Stainless steel machining)

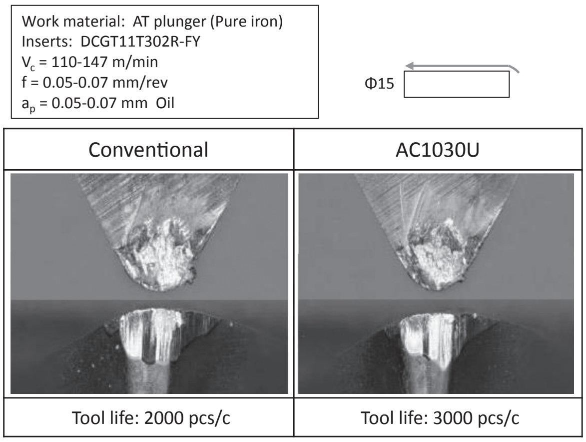



Fig. 16. Application example of AC1030U (Pure iron machining)

## 6. Conclusion

AC1030U, with the new PVD coating technology "Absotech Bronze," is a grade that offers both excellent finished surface quality and wear resistance in precision machining. Equipped with the new FYS type chip breaker for fine finishing, AC1030U offers excellent performance in precision machining of a wide range of work materials such as steel, stainless steel, heat-resistive steel, and pure iron. Furthermore, AC1030U will significantly reduce machining costs and improve productivity in precision machining.

• Absotech Bronze is a trademark or registered trademark in Sumitomo Electric Industries, Ltd.

### Technical Term

∗1 Physical vapor deposition (PVD): A method for physically depositing a thin film of a target material in its vapor phase onto the surface of a substrate.


### Reference

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## Contributors The lead author is indicated by an asterisk (∗).

### T. YAMANISHI*
• Hard Materials Development Department, Sumitomo Electric Hardmetal Corp.

### H. TAKESHITA
• Engineering Department, Hokkaido Sumiden Precision Co., Ltd.

### S. IMAMURA
• Assistant Manager, Hard Materials Development Department, Sumitomo Electric Hardmetal Corp.

### K. HIROSE
• Group Manager, Hard Materials Development Department, Sumitomo Electric Hardmetal Corp.

### H. FUKUI
• Assistant General Manager, Hard Materials Development Department, Sumitomo Electric Hardmetal Corp.