



Advanced Coating System iDS-720

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We have been developing the iDS coating system series with improved productivity and film performance since 2012 by reviewing the conventional coating systems from the basics. The iDS series has increased compatibility with a variety of applications by expanding the lineup of chamber sizes. This time, we have developed and launched iDS-720, which is suitable for mass production of tools and manufacturing of large punches and dies.

Keywords: coating, arc evaporation source, droplet

1. Introduction

Nissin Electric Co., Ltd. delivered the first coating system to a customer in 1985. Since then, the company has manufactured and sold coating systems for 36 years. In 2010, the business was transferred from Nissin Electric to Nippon ITF Inc. (hereinafter, “Nippon ITF”), one of group companies, which undertakes coating and sells coating systems.

Since 2010 (the year of business transfer), Nippon ITF has drastically changed the designs of the M series, the conventional coating system models. It newly commercialized the iDS series and has expanded the lineup of the chamber size. The details are reported below.

2. Performance Improvement of the M Series

We decided to change the designs drastically and improve the performance in response to requests from users to improve the performance of the conventional M series coating systems.

We started with improvement of the exhaust conductance (one of the numerical values that represent the ease of vacuuming), which is the basic performance of a vacuum system, and optimized the path from the vacuum chamber to the vacuum pump. We then conducted an in-depth study on the required capacity for a heater for heating inside the chamber, to enable the selection of a sufficient heater capacity for production equipment. We also improved the shield plate structure to operate a high-output heater.

3. Development of a New Arc Evaporation Source

The arc evaporation source installed in the M series was named the 2S type. The diameter and thickness of the cathode (which becomes the coating metal material and serves as the negative side of arc discharge) were 64 mm and 32 mm, respectively. Since the cathode was thick with a small diameter, the thermal conduction was limited, and

the arc current could not be increased above a certain limit. The material use efficiency of the cathode was low.

The design of the structure was changed to increase the diameter (160 mm) while reducing the thickness (12 mm), thereby improving the thermal conduction. This enabled operation with a large arc current (200 A).

We developed a new technology for the magnetic field structure. A permanent magnet was arranged on the back side of the cathode and was designed to rotate by a motor. This system achieved uniform consumption of the cathode and improved the smoothness (reduction in droplets*¹).

The system to rotate a permanent magnet is conventionally called the steered type. We named the new evaporation source “steer one.” Photo 1 shows the arc discharge from a titanium cathode electrode using the steer one evaporation source. This photo captured the moving range of the arc spot*² by keeping the camera shutter open for 0.5 seconds. Quick diffusion of discharge all over the cathode leads to uniform consumption of the cathode.

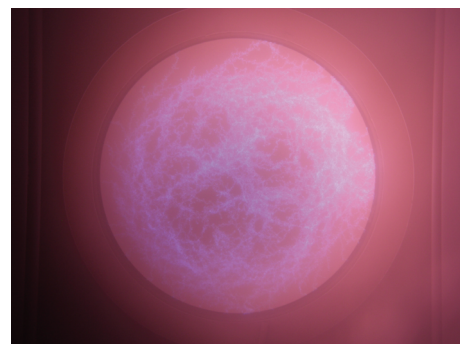


Photo 1. Arc discharge of the steer one evaporation source

Photo 2 and Photo 3 show electron microscope images of the surface of the test pieces, on which an Al-Cr-N film was formed under the same film forming conditions using the 2S type evaporation source and the

steer one evaporation source, respectively.

The steer one evaporation source reduced droplets and achieved a smooth surface.

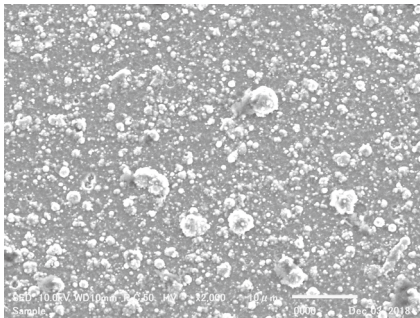


Photo 2. Surface of an AlCrN film by the 2S evaporation source (film thickness: 3.9 μm, mean roughness Ra: 0.24 μm)

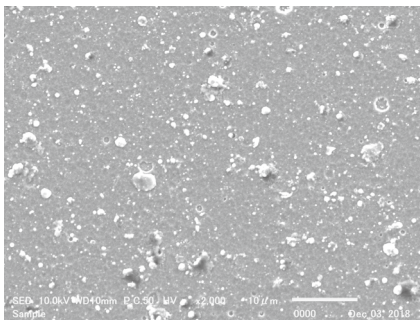


Photo 3. Surface of an AlCrN film by the steer one evaporation source (film thickness: 3.9 μm, mean roughness Ra: 0.14 μm)

4. Development of the New Coating System “iDS Series”

The abovementioned improvement of the exhaust conductance, heater, and shield plate, as well as new technologies, including the newly developed arc evaporation source “steer one,” were incorporated into the new system. The series was named iDS, or Innovative Deposition System. In 2014, the iDS-500 (Photo 4) was completed as the first model.



Photo 4. Appearance of the iDS-500

The same film type was formed on the same products, which were commercial job coatings on drills, by using the M500D (conventional model) and the iDS-500 (newly developed model), and the processing time was compared. The results are shown in Fig. 1. The M500D took 10.4 hours on average to process, while the iDS-500 took just 5.7 hours. This shows that the cycle time was significantly reduced. Gas exhaust in the reactor can be completed in a short period due to the increased exhaust conductance and the higher heater capacity, making it possible to reduce the time required for the initial exhaust and heating exhaust. In the bombardment processing, the higher degree of vacuum in the reactor produces the same effect in a shorter period. The new arc evaporation source “steer one” has increased the film forming speed, resulting in a shorter film forming time.

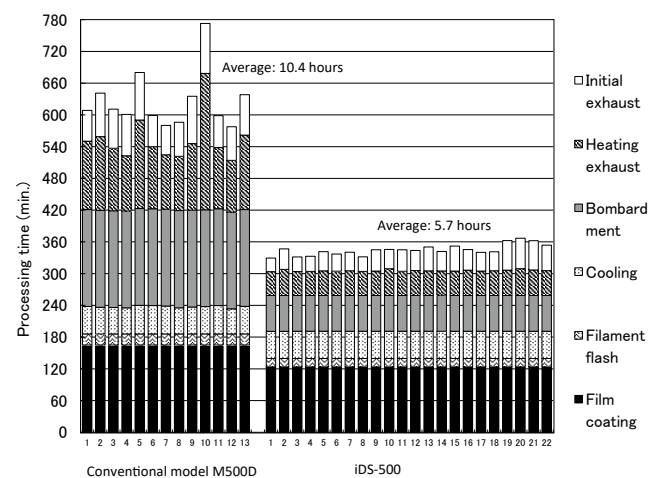


Fig. 1. Comparison of cycle time between the iDS-500 and the conventional model

5. Size Lineup of the iDS Series

As discussed above, the productivity of the iDS-500 was found to be high in terms of film performance and cycle time. However, the availability of the coating system in only one size made it difficult to apply to various usages. It was necessary to expand the lineup while maintaining the concept of the iDS.

The abovementioned iDS-500 was released in October 2014. In 2017, we marketed iDS-1000, an ultra-large coating system for automotive parts. Subsequently, the iDS-mini, a small coating system, was put on the market in June 2018 for new and re-grinded shank tools, such as drills and end mills.

Most recently, we have developed the iDS-720 (Photos 5 and 6). The objective was to offer a size in which large molds can be installed. The film forming targets are tools and hob cutters, which are expected to be processed in large quantities at a time.

When a large production quantity is expected, the coating system should be large and many base materials should be processed at a time to reduce the processing cost per base material. To expand such choices, it is necessary to offer the coating systems in various sizes.

The comparison table of the models of the iDS series is shown in Table 1.

Table 2 shows examples of film types that can be formed by the iDS series. They are publicly known film types. Respective companies develop multi-layered films and new films by adding different elements.



Photo 5. Appearance of the iDS-720

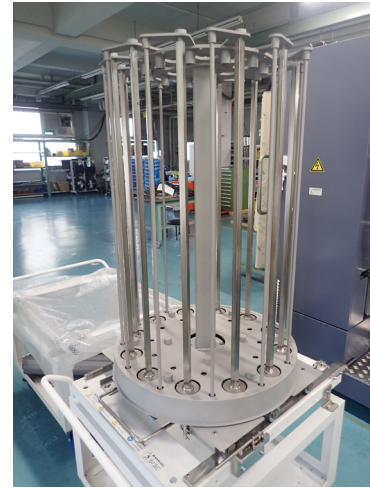


Photo 6. Jig for the iDS-720

Table 1. Lineup of the iDS series

| Model name | iDS-mini | iDS-500 | iDS-720 | iDS-1000 |
|--|---|---|--|---|
| Appearance (photo) |  |  |  |  |
| Effective film coating zone (mm) | φ450×H420 | φ500×H500 | φ720×H800 | φ1000×H1000 |
| Number of evaporation sources in the vertical direction | 2 | 3 | 4 | 5 |
| Number of surfaces on which an evaporation source can be installed | 3 | 4 | 4 | 6 |
| Maximum installation weight (kg) | 180 | 320 | 700 | 700 |

Table 2. Examples of film types that can be formed by the iDS series

| Film type | TiN | TiCN | TiAlN | CrN | AlCrN |
|-----------------------------|---|---|---|---|---|
| | Titanium nitride | Titanium carbon nitride | Titanium aluminum nitride | Chromium nitride | Aluminum chromium nitride |
| Color | Gold | Gray to purple | Purple | Silver | Charcoal gray |
| Film thickness (μm) | 2~4 | 2~4 | 2~4 | 2~4 | 2~4 |
| Vickers hardness (Hv25gf) | 1800~2200 | 2000~3000 | 2000~3000 | 1200~2200 | 2000~2500 |
| Abrasion resistance | Generally better | Best for High-load sliding environment | Best for High-temperature cutting environment | Best for High-load sliding environment | Best for High-temperature cutting environment |
| Heat resistance (°C) | 600 | 500 | 800 | 800 | 900 |
| Processing temperature (°C) | 400~480 | 400~480 | 400~480 | 400~480 | 400~480 |
| Usage example | General cutting processing General-purpose molds | Punches/dies Sliding parts | High-speed cutting High-temperature molds | Machine parts/engine parts Alternative to Cr plating | High-speed cutting High-temperature molds |
| Characteristics of the film | General-purpose films | Low friction coefficient High hardness | Oxidation resistance at high temperature | Abrasion resistance Heat resistance | Oxidation resistance at high temperature |

6. Conclusion

We developed the iDS series by drastically changing the design of the M series, the conventional film forming system models, and developing new technologies. The arc evaporation source, which is the important part of an arc ion plating system, has evolved from the previous 2S type to the steer one type, making it possible to improve the smoothness. The increased efficiency by using the material has reduced material costs by up to 50% compared to the conventional 2S type. We have also expanded the lineup in size to ensure applicability to various fields.

The effective film forming zone of the iDS-720, which is described in this paper, is equivalent to that of the previous model (M720). By taking into account user friendliness, the chamber height has been extended by 100 mm compared to that of the M720 to use the film forming zone more effectively. The strength of the jig table, in which the base materials are installed, has been increased to withstand a load of up to 700 kg. In the iDS lineup, this numerical value is equivalent to that of the iDS-1000, making it possible to process larger molds and a large quantity of base materials.

These products are characterized by high performance and user friendliness. We are confident that the products are satisfactory to our customers.

• iDS is a trademark or registered trademark of Nippon ITF Inc.

Technical Terms

- * 1 Droplet: A droplet is a metal particle that springs out when arc discharge is generated on a metal surface. Droplets cause the film smoothness to deteriorate.
- * 2 Arc spot: Arc discharge on a metal surface continues from one point to another while inducing discharge. The point where arc discharge occurs is referred to as the “arc spot.”

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

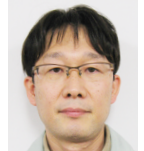
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