MATERION

TECH BRIEFS

Surface Coatings for Plastic Molds Using MoldMAX Family of Alloys

Materion Brush Performance Alloys produces a family of copper based alloys that are trade named MoldMAX® and PROtherm®. These alloys are processed to provide an optimal combination of hardness and thermal conductivity and are specified in a variety of injection and blow mold tooling applications. MoldMAX is available is several different hardness ranges, each with its own level of thermal conductivity. MoldMAX can be supplied with a typical maximum hardness of HRC 40. Maximizing the thermal conductivity of the molding system will decrease cycle times and achieve maximum productivity from your tooling.

MoldMAX alloys often have sufficient surface hardness to resist wear and abrasion caused by the injected resin or the mold parting line. Often, higher hardness is desirable to prolong the tool life in high wear applications, such as when using glass filled resins or in a high contact shut-off area. It is important to note that MoldMAX alloys are provided in the fully heat treated condition, and they cannot be heat treated to higher hardness. Furthermore, MoldMAX alloys cannot be nitrided or case hardened in any way. When additional hardness is required to enhance wear resistance and prolong tool life, MoldMAX may be coated with a harder material.

The increased hardness provided by coatings can be used to enhance the surface characteristics of injection or blow mold tooling used in the plastics industry. Simultaneously, these coatings are very thin, so that there is no noticeable effect on the overall ability of the mold to pull heat out of the resin. We will discuss mold coatings mainly from the perspective of improving the following important characteristics:

- Wear Resistance
- Corrosion Resistance
- Mold Release
- Ease of Repair/Stripping & Recoating
- Application Temperature

WEAR RESISTANCE

Wear resistance is normally related to the hardness of the applied coating. Typically, higher hardness is related to improved abrasive wear resistance. Most coatings are promoted on their ability to attain a certain hardness level. Hardness levels above HRC 90 are common today.

Coatings with lower frictional coefficients can provide enhanced surface lubricity and also improved adhesive wear resistance. It is important to understand the type of resins used in the mold to be designed. Certain types of resins, especially those that are glass filled, can be very abrasive to the mold surfaces. High injection pressure is another molding parameter that can increase mold surface wear. Understanding the molding parameters will influence the decision whether to coat the mold and the type of the coating used.

CORROSION RESISTANCE

Corrosion resistance is another important feature of a mold coating. The coating or base mold alloy must be able to withstand the corrosive nature of plastic resins along with elevated temperature exposure and moisture. This is critical when molding PVC, since compounds volatilized from the PVC resin can interact with moisture to form hydrochloric acid. (See “Processing PVC with MoldMAX® Tools” Tech Brief for more details). While copper alloys resist a variety of corrosive environments, the mold coating discussed here will typically enhance the overall corrosion resistance of the mold. Corrosion is also a concern when the mold is idle or in storage because of the possibility of condensed moisture forming on its surface. A mold that is run too cold is also more prone to condensed moisture.

As the resin flows into the mold, gasses build up ahead of the resin. As the gasses compress to pass through the vents, there is the possibility that they will spontaneously ignite, resulting in very small explosions around the vents. This process, commonly referred to as dieseling, can cause dramatic wear in the vent area and around the parting line.

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Therefore, when MoldMAX is used on a parting surface, it is important for the coating to extend beyond the parting line and into the vents.

MOLD RELEASE

Release of a plastic part from the tooling on ejection is also key benefit of a properly designed mold. Release characteristics normally relate to the coefficient of friction of the molding surfaces, and of course, proper mold design is important. Many of these coating aid in mold release, especially those that provide a low coefficient of friction. Low friction is essential for small or negative draft angles. It is important to realize that the coefficient of friction is not a material property, but a property of the contact system. It is influenced by the hardness, thickness, uniformity, and smoothness of the surfaces in contact. Furthermore, the coefficient of friction is actually a function of the load between the mating surfaces.

REMOVAL & REAPPLICATION

An often overlooked aspect of mold coatings is their ease of reapplication. In wear situations, it is important to realize that even the super-hard coatings which are promoted today can eventually wear through to the base material. These coatings also tend to be very thin, typically 0.0002-0.0003 inches thick, so there is not much coating material to wear through. In this case, it is important to be able to recoat the mold component to extend its service life. One of the challenges of the re-coating process normally involves removing the current coating without damaging the surface or softening the base material. Because these coatings are so thin, the surface quality of the coating will directly reflect the surface quality of the base metal. Over time, repeated application and removal of the coating and underlayer can degrade the surface quality of the base metal. This is a problem for optical quality molds. The ease of removal and reapplication of a coating is also important if the mold must be repaired or reconfigured by welding. Please discuss this issue with the coating supplier to ensure that the coating can be removed without affecting the surface of the base metal.

APPLICATION TEMPERATURE

Since most metals will soften when exposed to elevated temperatures, it is also important to limit the temperatures used in the coating process. Process temperatures above the limits shown below should be avoided unless some degree of softening of the base material can be tolerated.

Short time exposures to higher temperatures may be acceptable depending on the application. Some coating processes use temperature and time combinations that can cause considerable softening of the base material. To avoid degradation of the mold material, we can not over emphasize the importance of discussing these details with your coating supplier.

Maximum Process Temperatures		
MoldMAX HH	550°F	290°C
MoldMAX LH	550°F	290°C
MoldMAX XL	650°F	345°C
PROtherm	800°F	425°C
MoldMAX V	800°F	425°C
C18000	800°F	425°C

Prior to coating, the surface of the part being coated must be clean and free of oxidation. This means the part will typically be degreased and dipped in an acid solution to remove oxidation and other tarnishes. All copper-based alloys will have a natural copper oxide on their surfaces that must be removed for good coating adhesion. See "Cleaning MoldMAX Molds" Tech Brief for further details.

COATING METHODS

There are several methods used to apply the coating we discuss. One of the main concerns when considering a coating process is its application temperature. Elevated temperatures can soften most mold materials. In all cases, proper cleaning of the mold component prior to coating is one of the main factors that influence coating adhesion and quality. The coatings used for copper based alloys are typically applied using one of the following methods:

- Electroplating
- Electroless Plating
- Physical Vapor Deposition (PVD)

ELECTROPLATING

Electroplating is one of the most generally used and most traditional coating method. It involves immersing your electrically charged (cathode) part into an electrolytic solution. An anode, which is composed of the metal to be deposited, is also submersed in this solution. Application of direct current between the anode and cathode causes the anode to dissolve, forming metal ions that are then deposited onto the part (cathode). This process in normally performed at or near room temperature. Electroplating in a line-of-sight process, which means only those areas exposed to the anode will receive plating. Holes or recessed areas on the part may not be plated unless they can be oriented toward the anode. Plating thickness depends on the current density distribution over the part surface. This means that thicker deposits can build up on outside corners and edges (higher current density) and thin to no plating in deep recesses (low current density).

ELECTROLESS PLATING

Electroless plating involves a chemical reduction process whereby any catalytic surface in contact with the plating solution is coated uniformly regardless of part geometry. There is no electrical current involved. Nickel plating is the most commonly performed electroless process. This process also allows for co-deposition of phosphorous and/or PTFE. An advantage of electroless plating is that its thickness depends solely on the deposition rate and the immersion time, not on current density

PHYSICAL VAPOR DEPOSITION

Physical Vapor Deposition (PVD) coatings are applied in a vacuum chamber by vaporizing the coating material and accelerating it towards the part. There are several variations of the PVD process which are distinguished by their vaporization source, work piece ion bombardment and type of reactive gas atmosphere utilized. The introduction of a reactive gas in the reaction vessel gives rise to coatings of an inorganic compound instead of a metal. For example, nitrogen or methane may, respectively, produce a nitride or carbide coating. Because the PVD process is a line of sight process, the equipment set-up must be altered to apply a uniform coating on a complex shaped part. Application temperatures can be up to 900°F, which can soften the base material. Most PVD suppliers have low temperature processes available, which must be used on MoldMAX. Please discuss this option with your vendor.

COATING TYPES

An accompanying chart contains a description of the types of coating that can used with MoldMAX tooling to enhance the performance of your mold. There is normally no one correct coating to recommend for a given application, since there are performance trade-offs with each of them. The best way to use the accompanying chart is to investigate the coatings that have the desired attributes and then contact the appropriate vendors for additional details. Our list of coatings and vendors is by no mean complete but will hopefully serve as a guide in your selection process.

Nickel coatings are applied by electrolytic or electroless processes. Often, electroless nickel is co-deposited with phosphorous to make a hardenable coating, and/or with PTFE (Teflon®)to make a low friction coating. Nickel coatings are typically around HRC 50, although the phosphorous nickel coatings can be heat treated to around HRC 70. While the plating process itself is performed at or near room temperature, the hardening heat treat can be performed at a temperature high enough to soften the base material. When heat treating the nickel-phosphorous coating, it is important to limit the temperature to avoid softening the base material.

Diamond like Carbon (DLC) coatings take advantage of the natural hardness of diamond. These coatings are comprised of small particles of carbon in a random array of diamond-like crystalline structures. DLC coatings can achieve hardnesses greater than HRC 90. These coatings are typically deposited by physical vapor deposition, so be sure to discuss the application temperature with your coating supplier.

Chromium coatings are applied by electrolytic processes. These coatings are typically silver in color, and are typically around HRC 70 in hardness. These coatings can also be co-deposited with other materials, such as diamond-like carbon particles, to improve hardness and wear resistance.

Ceramic Coatings such as TiN, TiCN, CrN, CrC, BC, etc. are typically deposited by physical vapor deposition. These coatings are available in a wide variety of hardness ranging from around HRC 70 to HRC 90. Each one of these ceramics will also have a unique color, depending on which elements are deposited.

SAFE HANDLING OF COPPER BERYLLIUM

Please refer to the Materion Corporation publications “Safety Facts 104 - Safety Practices for the Chemical Processing of Small Copper Beryllium Alloy Parts”, and “Safety Facts 105 - Processing Copper Beryllium Alloys.”

Handling copper beryllium in solid form poses no special health risk. Like many industrial materials, beryllium-containing materials may pose a health risk if recommended safe handling practices are not followed. Inhalation of airborne beryllium may cause a serious lung disorder in susceptible individuals. The Occupational Safety and Health Administration (OSHA) has set mandatory limits on occupational respiratory exposures. Read and follow the guidance in the Material Safety Data Sheet (MSDS) before working with this material. For additional information on safe handling practices or technical data on copper beryllium, contact Materion Brush Performance Alloys, Technical Service Department at 1-800-375-4205.

COATING SUPPLIERS

The following is a list of companies that are capable of providing the coating that we discussed. This list is provided in order to make your job selecting a coating vendor easier. It is by no means an endorsement for any one company or a guarantee of coating quality. When working with a coating supplier, always provide them with the details of your mold design, mold material and type of resin so that they can provide a compatible coating.

Armoloy of Illinois, Inc.
(Armaloy, Armaloy XADC)
http://www.armoloyil.com

Bales Mold Service Inc.
(Electroless Nickel, Nickel PTFE, Hard Chrome)
http://www.balesmold.com

Bekaert Advanced Coating Technologies
(DLC)
http://www.bekaert.com/BAC

Bodycote
(BC)
http://www.boroncarbidecoating.com

Ionbond AG Olten
(TiN, TiCN)
http://www.ionbond.com

Oerlikon Balzers Coating USA, Inc.
(TiN, CrN, TiCN, DLC)
http://www.oerlikon.com/balzers/us

Poly-Plating, Inc.
(Nickel, Electroless Nickel, Nickel PTFE)
www.poly-ond.com

Richter Precision Inc.
(TiN, TiCN, DLC)
www.richterprecision.com

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SOME COATINGS SUCCESSFULLY USED ON MOLDMAX AND PROTHERM ALLOYS

Coating Type	Deposition Process	Typical Thickness micro-inches (microns)	Typical Coating Hardness	Typical Application Temperature	Color
Armoloy XADC®*	Electrolytic	100 - 300 (2.5 - 7.6)	HRC 90		silvery matte
Armoloy®* (Thin, Dense Chrome)	Electrolytic	100 - 300 (2.5 - 7.6)	HRC 72	< 140°F < 60°C	silvery matte
Chrome - Standard Hard	Electrolytic	100 - 500 (2.5 - 12.7)	HRC 68	130 - 140°F 55 - 60°C	silver
Chromium Carbide (CrC)	PVD	40 - 240 (1.0 - 6.1)	HRC 70		silver-gray
Chromium Nitride (CrN)	PVD	40 - 240 (1.0 - 6.1)	HRC 68		silver-gray
Diamond Black (Boron Carbide)	PVD	80 (2.0)	HRC 93	< 250°F < 121°C	dark gray
Diamond Like Carbon (DLC)	PVD	40 - 80 (1.0 - 2.0)	HRC 90+	200°F 93°C	black-gray
Nickel - Electroless	PVD	500 - 1000 (12.7 - 25.4)	"HRC 50 (as plated)"	180°F 82°C	silver
Nickel - Electrolytic (Engineering)	Electroless	500 + (12.7 +)	HRC 50		silver
Nickel/Teflon®† - Electroless	Electrolytic	500 (12.7 +)	"HRC 50, HRC 70 baked"	< 100°F (38°C), baked @ up to 750°F (400°C)	silver
Titanium Carbonitride (TiCN)	Electroless	40 - 160 (1.0 - 4.1)	HRC 92		blue-gray
Titanium Nitride (TiN)	PVD	100 - 200 (2.5 - 5.1)	HRC 82	950°F 510°C	gold

*Armaloy and Armaloy XADC are registered trademarks of The Armaloy Corporation.

†Teflon is a registered trademark of E. I du Pont de Nemours and Company.

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