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Discussion Topics and Threads on Thermal Spray

Compiled and edited by Dr. R.S. Lima, National Research Council of Canada (NRC). These questions and answers were extracted from the e-mail discussion group of the Thermal Spray Society of ASM International. The content has been edited for form and content. Note that the comments have not been reviewed. To sign up to the e-mail discussion group:

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Question 1

Removing chromium carbide-based coatings without damaging the substrate. What is the best method for removing chromium carbide-based coatingswith out damaging the substrate?

Answer 1.1: You may try sandblast, which damages the substrate a little.

Answer 1.2: You should use alumina-zirconia as grit-blasting material, because it is a very tough material and much better than white or brown fused alumina.

Answer 1.3: You did not mention the substrate material, shape, or the method used to apply the unwanted chromium carbide base. In my experience the best removal method with least damage to the substrate is grinding. The substrate would necessarily need to be flat or cylindrical. Other abrasive methods, like grit blasting, would change the substrate surface and likely impart deforming stress to the component. Additionally, the process is not very selective; i.e., you lose more material at edges and ridges.

Question 2

Applying coatings on nickel-plated parts. I need to quote for a customer concerning HVOF-sprayed WC10Co4Cr coatings on steel parts plated with about 0.001 to 0.002 in. of nickel. Parts are small in dimension, about 1 in. height by 8 in. long, and made of steel. An HVOF spraying coating over plated materials seems not to be common. Has anybody ever done/seen HVOF coatings over plated materials?

Answer 2.1: A question similar to yours was asked a few years ago in this e-mail discussion list, and three replies were provided by list members. I am forwarding this question and the respective answers to the e-mail discussion list again. They may be useful.

Question: We are currently involved in applying chrome oxide onto a ring that has been plated with electroless nickel. The drawing specifies that we coat the surface with chrome oxide after nickel plating. While the entire ring has been plated, we are only applying the chrome oxide to a 1 in. strip of the outside diameter. It is intended that the electroless nickel remain underneath the chrome oxide. Has anyone done this in the past? Or should the electroless nickel be entirely removed by grit blasting? Our current procedure is:

1. Blast with 60 grit aluminum oxide at approximately 50 psi.
2. Apply 2 mils bond coat of arc sprayed nickel aluminum.
3. Powder combustion spray with chrome oxide 0.005 in. finished thickness, subsequently to be ground.

One of my concerns is that, at times, the nickel-plating blisters off during grit blasting while most of the time it remains intact.

1st Answer: We did something similar years ago and found that by going to a 220-grit we could keep the plating intact; however, you do lose some mechanical bonding properties. The thickness of the nickel plating may also have an impact on its ability to remain bonded.

2nd Answer: We have come across this type of application several times in the past. Initially, we approached the issue the same as you. We have since found it reasonable to apply the coating onto the nickel plating, but we look for the part to be grit blasted prior to flash plating and a maximum of 0.001 in. of plating (typically, 0.0005 in.). We would probably use the bond coat also.

3rd Answer: I do not have experience with blasting the plating and coating over it, but I have to say I do not agree with this approach. The bond has to be damaged even if the plating appears to remain in tact, so complete removal under the area to be coated is the way I would want it done (if the above is not possible).

Answer 2.2: Mask the adjacent area and grit-blast nickel off completely in the coating area (it is easy, grit No. 16 or No. 24 will do). When spraying WC-based, let some overspray (run out) to go over remaining nickel (1–2 mm band). We deal with such situations almost every day.

Question 3

An alloy with low aluminum solubility in Ni-base alloys. A retort furnace tooling is made from Ni-base alloys. The furnace operates at 2000 °F and has a strong H_2-reducing atmosphere with fluoride and chloride gasses. Aluminum vapor condenses on the tooling, diffuses, saturates, and forms a eutectic. Tooling then erodes and distorts. Is there an alloy with low aluminum solubility that can be used to clad or coat the tooling to improve furnace life? I am considering some ceramic coatings, but a metallic with no aluminum solubility would be ideal.

Answer 3.1: Have you considered the metal infusion surface treatment (MIST) process? It is not a thermal spray approach, but there are claims that it works for molten metal resistance applications. You can find more info on this approach at http://www.cccintl.com/pdf/CSM_whitepaper.pdf.

Answer 3.2: In the late 1980s, I tested CVD-SiC-coated graphite lances and monolithic SiC lances in molten Zn, Al, and Cu; the improvement was limited/short-lived. We also tested α-Al_2O_3, APS-coated $MoSi_2$; the results were better but the cost prohibitive for the majority of foundry/melt shop applications. As to TiC, it is used as a grain refining, Al-alloy modifying agent. Molten Al nucleates on its surface epitaxially.

Question 4

PVD as gold plating process. Can the physical vapor deposition (PVD) process be used for gold plating? If positive, what are the economics of PVD over standard chemical plating?

Answer 4.1: Yes, you can PVD gold thin layers. However, you may or may not get what you want depending on your application. If it is aesthetics that you are after, it is not trivial to attain the same color and/or luster. The comparative economics will depend on several factors, some of which include the exact PVD process, the associated optimized parameters specific to your application, and the overall costs associated to electroplating in your area (including cost of environmental issues such as treatment or disposal of effluents associated with electroplating).

Question 5

Thermal spray coatings employed as armors. I am interested to learn if there are potential application areas for the use of thermal spray coatings in armor in conjunction with or as an alternative use to those of conventional hot-pressed/sintered ceramics and composite materials (non thermal sprayed). Are there unique needs that the characteristics of the thermal spray coating would provide a benefit over that of traditional hot-pressed/sintered ceramic and composite armor?

Answer 5.1: I remember a display at one of the thermal spray conferences where a small company was using what I believe was water-stabilized plasma (WSP) to create alternate metallic and ceramic layers to make light armor structures. I believe that it was in the late 1990s.

Question 6

Thermal spraying Teflon. Do you have any information regarding Teflon spraying technique? I am looking for Teflon coating applications on paper rolls.

Answer 6.1: We spray fluoropolymers on a daily basis. There are different types of fluoropolymers, which are chosen depending on the application. Several factors will influence the type of polymer you will spray, for example: (i) whether you spray Teflon in powder or liquid form, (ii) required cure temperature, (iii) end use of product, or (iv) FDA compliant.

Question 7

Hardness value of Mo coatings. I need some information about the hardness value of molybdenum. I have a customer. One of their specifications is 75 hardness values according to 15N scale. We cannot achieve this hardness value. These are my questions:

- Is a 75 hardness number value (15N scale) too high?
- Does anyone get this number?

Answer 7.1: I will give you a general answer on the hardness number values of thermally sprayed molybdenum coatings. Concerning plasma spraying you will probably have some challenges to achieve the result requested by your costumer.

- Depends much on the process used.
- If Mo is flame sprayed, with slow wire speed and excess oxygen in the combustion, hardness increases dramatically.
- If Mo is arc sprayed using standard parameters, then the molybdenum coating is very soft.

Mo coatings applied with flame spray have been used for years as a hard, self-lubricating type of coating in many applications. However, now the material is so expensive it is seldom used in industrial applications.

Answer 7.2: The 75 HR-15N hardness number value sounds about right. Technical bulletin indicates typical hardness 65 to 70 HRA, depending on parameters set. This roughly is equivalent to 74 to 79 HR-15N.

Question 8

Anti-fretting coating. I have a customer who is designing a rotor hub and cone using titanium to save weight. The cone is installed in the hub and is under constant compression; there is some movement between the two. We are asking for recommendations for coating the cone to decrease any possible fretting between the two.

Answer 8.1: You need high toughness and low residual stress coating. Options could be Cu-Ni-In or Ni-Cr-Si-Fe-B alloys. Note: some references indicate that the titanium immigrates to the Cu-Ni-In coating at high temperature.

Answer 8.2: There are numerous approaches, some wellknown and others less-known, with different advantages and disadvantages depending on the specifics of your application. You might consider the following:

- APS Cu-Ni-(In)
- Low plasticity burnishing
- Shot peening
- Multimodal or nanostructured WC-Co(Cr)
- Al-bronze coating
- Mo coating
- Mo-Ni-Al coating

Answer 8.3: A question similar to yours appeared on the TSS discussion list some years ago. I am posting this question and respective answer again. They may be useful.

Question: Background: heavy lift helicopter used for construction, logging, and fire fighting. It employs Ti-6Al-4V forged helicopter rotor hubs. The splines of the rotor hubs are fretting, and a spray repair is needed. The application of a LPPS coating followed by machining was tried, but the coating deteriorated (information on the coating material that was used is unavailable at this time). The stresses of reassembly caused shearing of some of the coating, and the pounding that created the original fretting caused any surviving coating to deteriorate. Air spray is unacceptable due to the risk of formation of alpha case during processing.

- Is there anyone that can provide a high-velocity low-pressure plasma service to replace the LPPS?
- Should the spline be machined before coating deposition?
- Would a soft coating material such as Cu-Ni-In (which was used in titanium disk dovetails to repair fretting) be suitable or should a harder and tougher material be used?

Answer: The spraying of Ti-base alloys for this job is constrained by two main factors:

- It limits the part temperature during spray due to the phase stability issues, as mentioned.
- For this antifretting application, the poor sliding and galling resistance of Ti alloys in general.

From these viewpoints the Ti coatings should be either difficult to apply or not function properly. Depending on the microslip amplitudes or if the slip is partial or large, fretting may take the form of either fretting fatigue or fretting wear. In any case, due to the certain degrees of microslip occurring, any lubricity from the coating to be applied would somewhat be effective in reducing fretting. Also, higher strength retards the crack initiation, and toughness raises the resistance to crack propagation under fretting fatigue. Hence, the mentioned Cu-Ni-In or the chromium carbide-NiCr would be candidates to consider; the latter coating being tougher to a greater degree because of its higher hardness. Another class of coatings to consider might be the abradable types, such as the Ni-graphite. These are easy-cutting or easy-abrading coatings, but cohesively strong, lubricious, and tough too. This coating also has the advantage of being sprayed at low temperature (flame spray) and used in the as-sprayed state.

Answer 8.4 : Due to very low conductivity and heat-dissipation rate combined with high reactivity, Ti-alloy components necessitate precise temperature control during coating operations. An automated cooling system may turn out to be quite helpful in LPPS, APS, and HVOF deposition of Ti coatings.