Modern Applications of the Low Pressure Cold Spray

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The main advantage of the cold spray process is minimal influence to the substrate properties with sufficiently high bond strength. This advantage allows metal coating to be applied to the specific objects which were never subjected to the thermal spray process. The examples of the low pressure cold spray application to the glass objects, magnet sensors and electronic elements are presented and discussed.

1 Introduction

The gas dynamic spray or cold spray process [1, 2] offers an advantage of thick metal coating deposition with the minimal influence to the substrate. This distinctive feature allows the application of the process to the objects usually do not exposed to the thermal spray. The cold spray may replace some technological processes or simplify them or, in some cases, create new technological possibilities. Following the olimpic motto “faster, higher, stronger”, cold spray may become quite powerful and rather „hot“ then „cold“ [3]. Nevertheless the reasonable decrease of the deposition rate and efficiency [4] may open multiple applications of the process.

2 Coating - Substrate Interface

The coating deposition with the minimal influence to the substrate means that there is no any diffusion zone at the coating-substrate interface and thermal stresses do not cause the substrate deformation. Typical cross section of aluminum coating sprayed by Al-SiC powder blend at steel is presented in Fig.1. Optical micrographs demonstrates the uniform coating without diffusion zone at the interface.

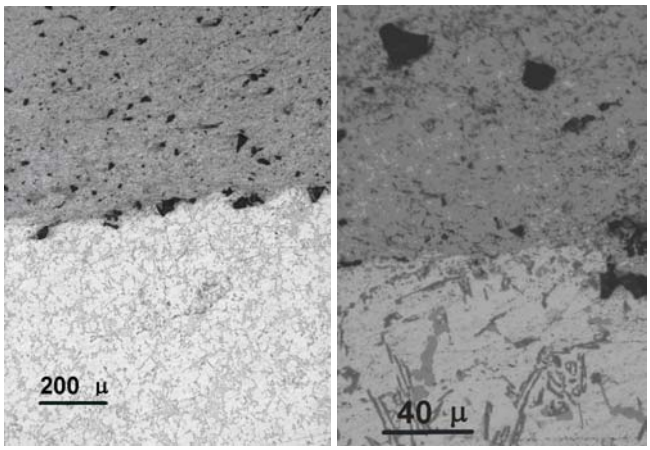

Fig. 1. Optical micrograph of Al-SiC coating at steel interface.

Observation at higher magnification and elemental composition test demonstrate the absence of any interpenetration of coating and substrate materials at much shorter distances. The interface of aluminum coating at cast iron at the scale of several micrometers is presented in Fig.2. The coating was spayed with Al – Al_2O_3 blend. The left image is obtained in characteristic Al emission and right one in characteristic Fe emission.

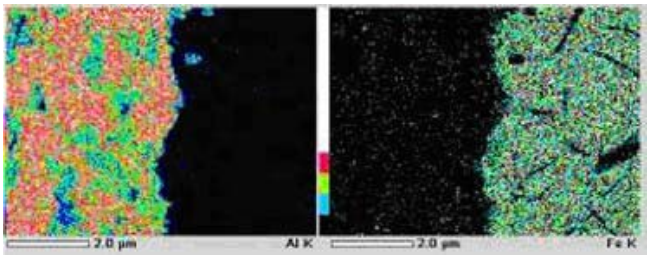

Fig. 2. Cross section of Al-Al_2O_3 coating at cast iron interface in characteristic Al and in characteristic Fe emissions.

The absence of the coating influence to the substrate up to a few micrometers scale is the base for the multiple cold spray applications.

3 Low Pressure Cold Spray Equipment

Modern Low Pressure Cold Spray equipment is designed as portable or mobile system for both manual and robotic operation. Commercial DYMET and SST (in North America) systems are now explored for various applications. Compact spraying gun, control unit and open powder feeders are the main components of the system.

Fig. 3. Portable low pressure gas dynamic spray system DYMET-413.

Spray gun includes light weight air heater and supersonic nozzle with replaceable nozzle insert as a changeable element eroded by ceramic component of powder blend. Radial powder injection downstream of the nozzle throat allows the use of open powder feeders. The spraying gun may be used in manual or robotized operation.

4 Application

The possibility to deposit thick metal coatings with high bond strength on temperature sensitive materials prompts the process application to contact lines at heated and photovoltaic glasses. Those contact lines for the 10 – 100 amperes electric current are used now at heated glasses of planes, ships and locomotives (Fig.4).

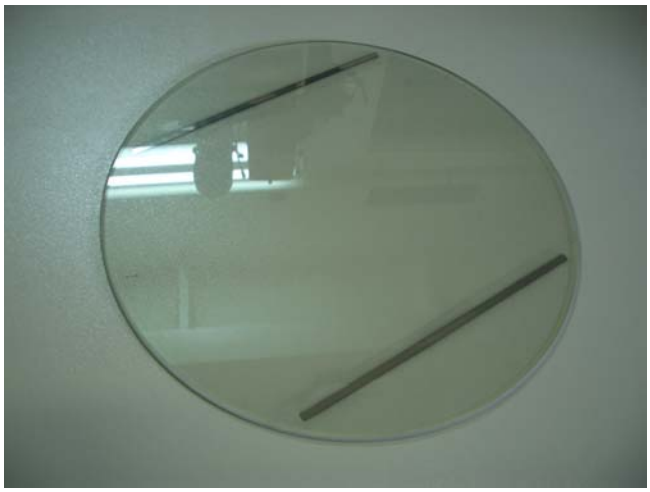

Fig. 4. Contact lines at heated glasses.

The metal coating deposition to glass surface by the cold spray may be used to create contact pads at similar objects to replace the process of vacuum local coating deposition to optical electronic devices (Fig.5).

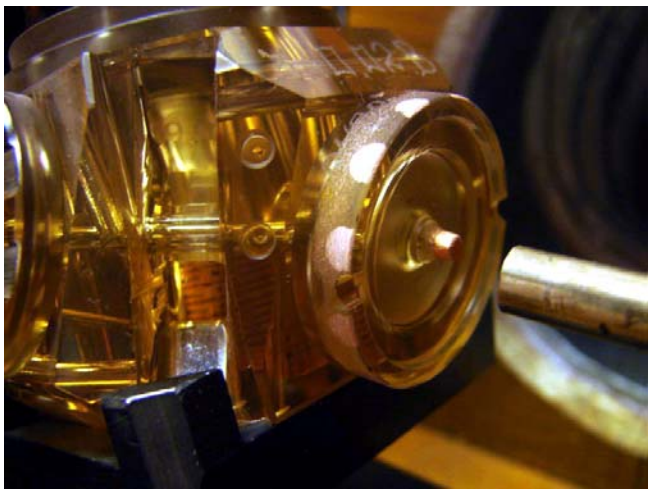

Fig. 5. The contact spots deposition to the optical electronic device.

The main requirement for the coating deposition process in electronics is the undamaged state of the substrate. The vacuum deposition is ideal process for that, but the layer thickness is limited. To create thick layers at semiconductors vacuum deposition may be followed by the cold spray or in some cases replaced by the cold spray process.
To prevent tin diffusion to the semiconductor volume at zones of contact soldering thick aluminum or nickel barrier may be sprayed to the semiconductor surface. The process of aluminum coating deposition to the surface of Bi_2SbTe semiconductor plates is presented in Fig.6.

Fig. 6. Spaying of aluminum barrier layer to the surface of Bi_2SbTe semiconductor plates.

High value of bond strength to the glass and ceramic surfaces allows the use of cold spray to replace DBC technology in production of small lots of special ceramic circuit boards. Contact lines and pads may be deposited with the thickness up to 1 mm (Fig.7).

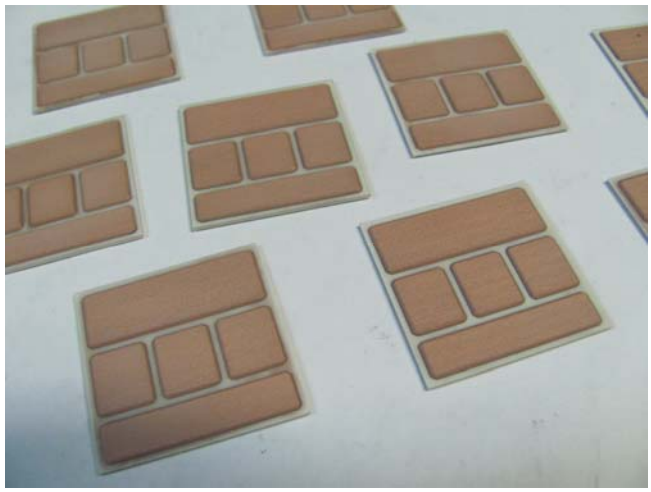

Fig. 7. Contact pads at AlN ceramic plates deposited by gas dynamic spray.

Because of the low temperature of the process the coatings may be sprayed even to the surface of already assembled electronic devices.

Powder compacted materials like magnets can not be electroplated in solutions. The heating also has a harmful effect on magnets. The gas dynamic spray is the simple and convenient processes to deposit metal coating to such an objects (Fig.8).

Fig. 8. Magnet sensors and UHF ferrites coated by low pressure cold spray process.

The base material conservation under the restoration process is the main requirement of antique objects restoration. The property of the gas dynamic spray process to save the substrate material is highly appreciated by restorers. This process is applied both to the antique technical objects, like cars or airplanes and antique art objects, like metal sculptures. In some cases the use of gas dynamic spray is the only applicable method of restoration.

Fig. 9. Restoration of the lost copper coating at the antique sculptures of Isaac Cathedral in Saint-Petersburg.

Portable DYMET equipment has been used to restore lost zinc coatings at the antique rotary elements of Angel at the Cross rotating sculpture at the broach of Saint Peter & Saint Paul Cathedral in Saint Peter & Saint Paul Fortress and to restore lost copper galvanic coating at the antique sculptures of Isaac Cathedral in Saint-Petersburg (Fig.9). Because of equipment portability the restoration process in both cases was fulfilled without antique elements and sculptures dismantling. The restoration of other Isaac Cathedral sculptures is continued now.

5 Conclusion

The possibility of the thick metal coating deposition without negative effects of heat is the base of the multiple application of the low pressure cold spray. Inspite of relatively low deposition efficiency and deposition rate the low pressure cold spray becomes cost-effective process in multiple applications because of high bond strength, simple use and undamaged state of the materials coated. New applications continue to appear.

6 Literature

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