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Effect on Hardness and Composition by the Coating of Ni-TiO_2-Al_2O_3 & Ni-Al_2O_3 on Tungsten Carbide Cutting Tool

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Abstract
Nano-structured composite layers (NCLs) find their potential applications in industry due to increased hardness, wear resistance and corrosion resistance. Many methods such as Chemical vapor deposition (CVD), Physical Vapor Deposition (PVD),spray coatings, electro deposition etc. have been reported in literature for synthesis of NCLs. Grain structures of electrodeposited layer can be controlled by controlling current, pH of the bath solution, agitation etc.; which improves the micro hardness , wear resistance and corrosion resistance of the composite coatings. Today in industry electrodeposited coatings are gaining more importance due to their low cost, ease and simplicity of operation of composite coatings for tribological applications of cutting tools. Ni is one of the most important hard coating materials and is widely used metal matrix. Generally, composites containing dioxide and nitride (like TiO_2 and TiN) are preferred for high wear resistance; high micro hardness, improved corrosion resistance, and high temperature oxidation resistance as compared to pure metal electroplating.TiO_2 nano-particles have good mechanical properties and can be used as secondary phase to improve the hardness of Ni coatings. In this paper Ni-TiO_2-Al_2O_3 & Ni-Al_2O_3 composite coatings are employed on WC cutting tool via electro-deposition. The composite layers are characterized using scanning electron microscopy (SEM), Vickers micro-hardness tester. The surface morphology of the coated layers shows the deposition of fine grained structures (cauli-flower like) at low currents, which increases the strain produced due to lattice defects and act as a basis for increase in hardness. The co deposition of TiO_2 & Al_2O_3 with Ni is confirmed by Energy Dispersive Spectro-photograph (EDS).

Keywords
Electrodeposition, Vickers Micro Hardness Tester

I. Introduction

Electro deposition is the process of coating a thin layer of one metal on top of a different metal to modify its surface properties. Electro-deposition is one of the challenged processes for improvement of the surface. Specially, it is used for the improvement of mechanical properties such as wear and hardness properties of the coating surface. These have the large projected applications for automotive parts, aerospace, printed, electrical contacts, jewelry, musical instruments, soft metal gaskets, and decorative door, light and bathroom fittings. The Nano-sized particles is used by most the researchers for improving, micro hardness, corrosion resistance. In this electro deposition process Ni-TiO_2-Al_2O_3 & Ni-Al_2O_3 composite coatings are employed on WC cutting tool

In economic point of view electro deposition is an appropriate technique which is used in industries. In electro-deposition process the grain size is major concern, this type of composite coating should ideally be developed at lower temperature range by the process of Electro deposition. Again, electro deposition is simple process for operation and by which uniformly deposited on the specimen surface. Electrodeposition appears to be one of the most suitable method because of low cost, simple operation, ease of control and high production rate.

II. Experiment Analysis

Electro-deposition is one of the practical methods to make nanostructure materials. Figure 1 shows a simple setup of electro-deposition system. In this system the electro deposition process is controlled by Potentiostat/ Galvanostat (GAMRY Referance600) instrument. A hot plate is used to control the temperature of solution. A specially designed three electrode electro deposition cell was used for electro deposition of Ni-TiO_2 (Fig. 1) where cutting tool was working electrode, Ag/AgCl as reference electrode and pure Ni act as counter electrode (anode). Hard Nickel bath solution was prepared by adding appropriate amount of chemicals in 150 mL distilled water. The beaker was heated on a hot plate and maintained at 45-50°C with continuous magnetic stirring.

Fig. 1: Setup of Electro-Deposition Process

The temperature was maintained by the use of a hot plate and the electro-deposition was controlled by a DC source. Scanning electron microscopy (SEM) can be used for qualitative surface morphology Analysis and energy dispersive spectroscopy (EDS) is a technique to determine the chemical composition of a material. The electrical current was kept a constant value of 24.4 mA for Ni-$TiO_2Al_2O_3$ coating and 23 mA for Ni-Al_2O_3 coating throughout the experiments and the corresponding voltage varied from approximately 0.7-0.85V for both coatings. A Nickel plate was used as anode whereas the prepared specimens were used as cathode. The pH of the plating solution was maintained by adding sulphuric acid (Increasing pH). The pH was maintained (pH 5.76) in both coatings.

III. Result analysis

A. Micro Hardness Measurement

Micro hardness values measured at different points on the surface shows that the Micro- hardness readings are homogeneous. Table 1 shows the variation of micro hardness values measured on the Ni- TiO_2 Al_2O_3 coated surface 66.3HRC and for Ni- Al_2O_3 coated surface 55.8 HRC. From the experiment it is clear that with increase in TiO_2 in Nickel bath concentration the micro hardness value increases. For addition of TiO_2 also similar trends were observed. Surface mechanical property is the outcome of particle co-deposition along with Ni grain size and texture obtained by the deposition process. From both the figure it is clear that Ni- TiO_2 Al_2O_3 composite coating exhibits more hardness as compare to the Ni- Al_2O_3 coating.

Table 1: Micro Hardness Measurement

Material	Rockwell Hardness
Titanium dioxide and Alumina oxide	66.3HRC
Alumina oxide	55.8 HRC

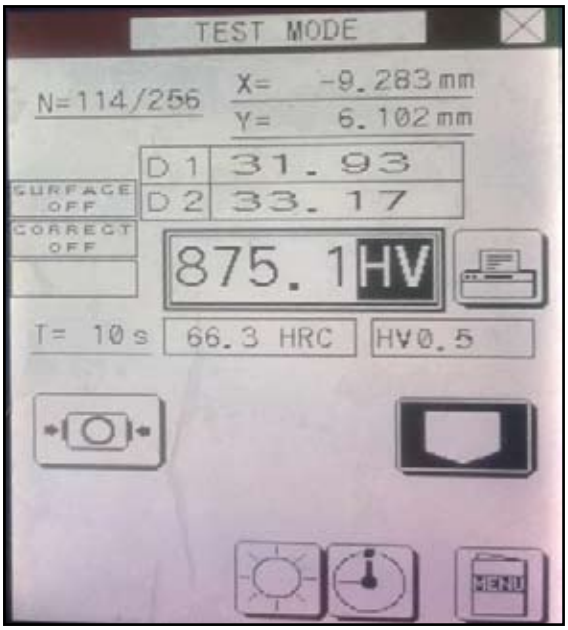

Fig. 2: Micro Hardness of Ni- TiO_2 Al_2O_3 Coated Specimen

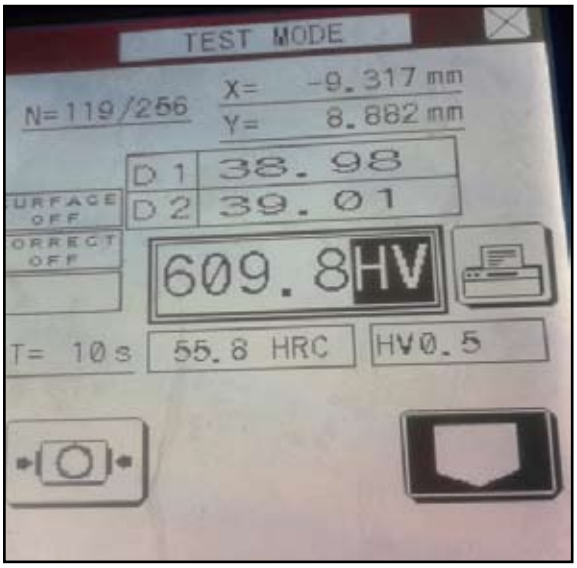

Fig. 3: Micro Hardness of Al_2O_3 Coated Specimen

C. Scanning Electron Microscopy and EDS Result

Microstructure analysis on the coated surface as well as on the cross section was carried out with scanning electron microscope (SEM). Fig. 5, 6 shows SEM micrographs of sample deposited with Ni- $TiO_2Al_2O_3$ and the Ni-Al_2O_3. The particle size of the Ni-$TiO_2Al_2O_3$ coating is fine as compare to the Ni-Al_2O_3 coating and its look like a lotus flower and cauli-flower like (dirt –repellent). To determine the chemical composition of the different phases observed in fig. 7, 8 energy dispersive spectroscopy (EDS) study was performed on different region on the coated surface. The deposition of TiO_2 & Al_2O_3 with Ni is confirmed by Energy Dispersive Spectro-photograph (EDS). In fig. 7, the spectrum confirms the presence of Ti along with Ni and other particles and fig. 8, the spectrum confirms the presence of Al along with Ni.

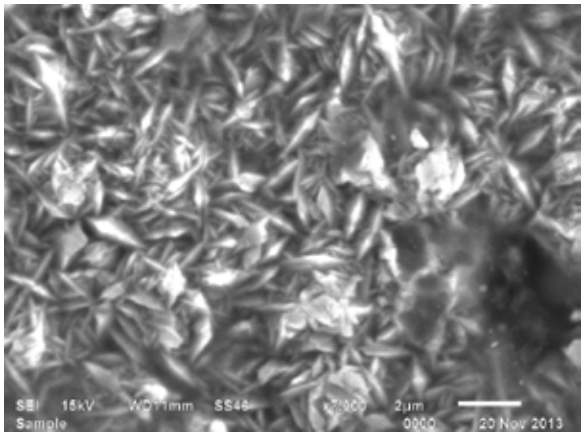

Fig. 4: SEM Micrograph of Tool Bit coated with Ni-$TiO_2Al_2O_3$

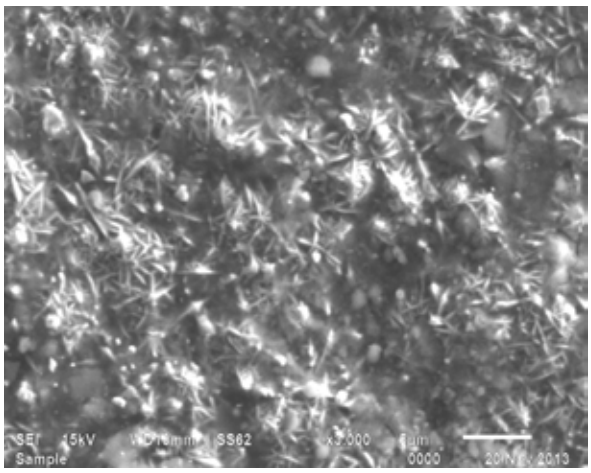

Fig. 5: SEM Micrograph of Tool Bit Coated With Ni-Al_2O_3

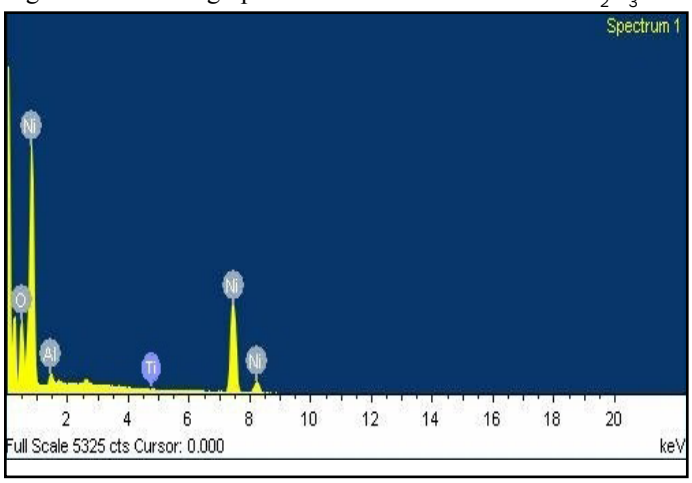

Fig. 6: EDS of Ni-$TiO_2Al_2O_3$ Coated Specimen

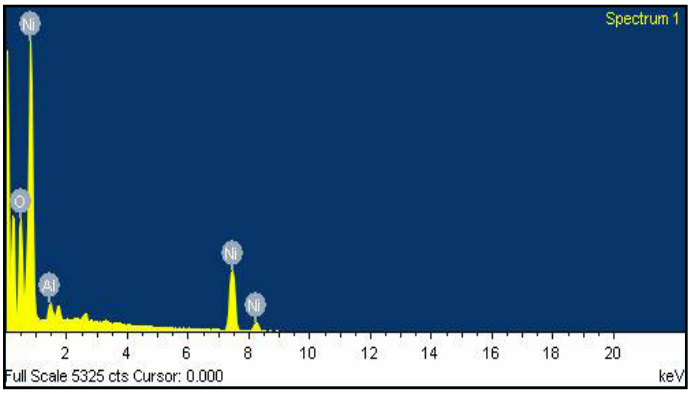

Fig. 7: EDS of Ni-Al_2O_3 Coated Specimen

IV. Conclusion

Ni-$TiO_2Al_2O_3$ and Ni-Al_2O_3 coating was done successfully on different Tungsten carbide tool bits by electro-deposition method. The composite layers are characterized using scanning electron microscopy (SEM) and Vickers microhardness tester. Micro hardness measurement of the coating shows that Ni-$TiO_2Al_2O_3$ coating has high micro hardness value as compared to Alumina oxide coating. Excessive addition of titanium can increased more amount of hardness. The surface morphology of the coated layers shows the deposition of fine grained structures (cauli-flower like) at low currents, which increases the strain produced due to lattice defects and act as a basis for increase in hardness. The deposition of TiO_2 & Al_2O_3 with Ni is confirmed by Energy Dispersive Spectrophotograph (EDS)

The hardness of the resultant coatings is found to be 66.3HRC for Ni-$TiO_2Al_2O_3$ coating and 55.8 HRC for Al_2O_3 coating depending on the particle volume in the Ni matrix. The SEM shows that the particle size of the Ni-$TiO_2Al_2O_3$ coating is fine as compare to the Ni-Al_2O_3 coating and its look like a lotus flower and cauli-flower (dirt-repellent).

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