# MECHANICAL PROPERTIES OF WC-CO BY NITROGEN ION IMPLANTATION: IMPROVEMENT OF INDUSTRIAL TOOLS

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*Abstract*

Ion implantation of WC-Co has been widely investigated for the improvement of wear resistance, but rarely for friction behavior. Although friction is closely associated with wear, more factors influence friction than wear, and low wear does not generally lead to low friction. Therefore, we focus our study on the effects of ion implantation on the mechanical properties in WC-Co cermets, with particular interest in tool industry applications.

## INTRODUCTION

The effects of nitrogen ion implantation on the properties and the characters of WC-Co cemented carbides were studied. Ion implantation is a surface modification technology to produce new materials on the surface by impingement of high energy ions from the heavy ion accelerator. This technology is suitable for the surface treatment of the precision mechanical parts. Ion implantation of WC-Co has been widely investigated [1-5]. We focus our study on the effects of ion implantation on the mechanical properties in WC-Co cermets, with particular interest in tool industry applications.

This study is intended to improve the quality of precision and life of PCB commercial drill.

## A GAS ION IMPLANTER

Figure 1 shows the schematics of the gas ion implanter.

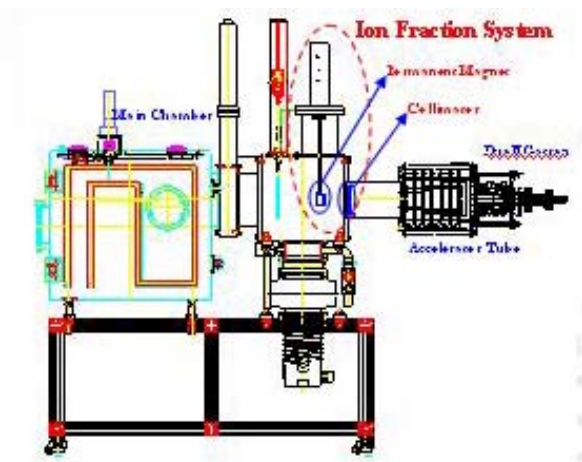



Figure 1 : A gas ion implanter for the ion implantation of PCB drill.

The detail specifications of implanter components are as followings:

- DuoPIGatron Ion Source:
  - Thermal cathode : W Filaments
  - Intermediate Electrode : Mild Steel, Cone Angle of 30 degree
  - Beam current : 20mA
  - Energy : 50 keV
- Vacuum System:
  - Pump : Oil Diffusion
  - Ultimate Pressure : 4 x $10^{-6}$ Torr
- Ion Diagnostics:
  - Scanning Faraday Cup : Th-W, 5mm diameter

The simple gas implanter can be utilized for developing various types of ion sources through function tests of ion sources as well as for developing sophisticated surface treatment technologies to be used in mass production of small piece products. This implanter designed specially for ion beam treatment of PCB drill..

## EXPERIMENT

The nitrogen ions are generated using by duopigatron ion sources up to 10 mA, 40 keV and accelerated up to 120 keV. The ion source can be considered $N^+$ and $N_2^+$ species as according with the plasma generation mechanism of a ion sources. Cobalt cemented tungsten carbide drill (WC-Co, Co:6%), 0.15, 0.3 mm in diameter (Figure 2), were used as samples. The WC-Co samples were implanted with nitrogen ion N at energy of 70 keV, 90 keV, 120 keV beam intensity of 2μA/cm$^2$. And with doses of 1 x $10^{17}$ ~ 1 x $10^{18}$ atoms/cm$^2$. Micro hardness tests were carried out on a Nano-indenter XP (MTS). Polished WC-Co plates were used for the micro hardness and modulus tests. Ion implanted WC-Co PCM drill bits, 0.15, 0.3 mm in diameter, have tested in actual operating practice.

## DISCUSSION

Figure 3 and Figure 4 show the results of the measured micro hardness and modulus and the results of micro hardness measurements as a function of dose are shown in Table 1. These show that optimum hardening occurs around 5 x $10^{17}$ atoms/cm$^2$. A maximum hardness increases of approximately 40 %.

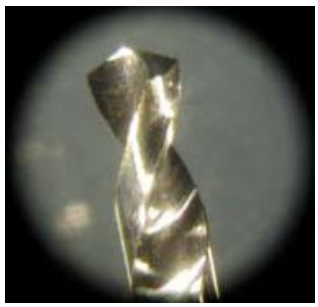


Figure 2 : The shape of PCB drill.

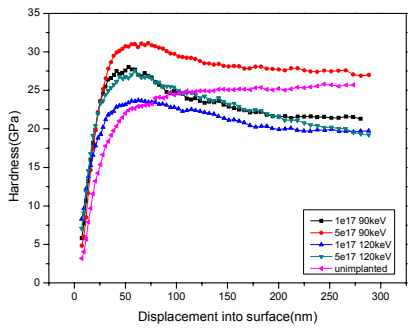



Figure 3 : The results of Nano-Indentation(Hardness).

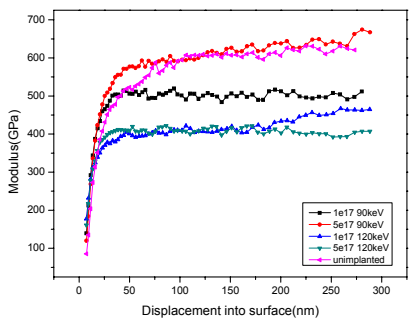
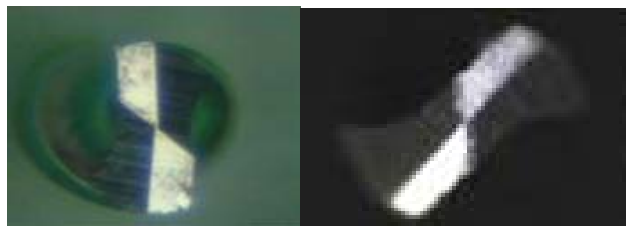



Figure 4 : The results of Nano-Indentation(Modulus).

Table 1: The hardness of unimplanted and implanted WC-Co

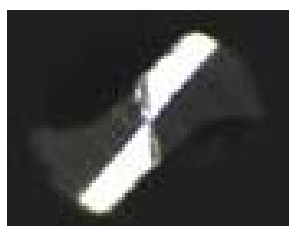
| Specimen | | Hardness(Gpa) |
|---|---|---|
| Unimplanted | | 22.649 |
| 90 keV | $1x10^{17}$ atoms/$cm^2$ | 28.033 |
| | $5x10^{17}$ atoms/$cm^2$ | 31.124 |
| 120 keV | $1x10^{17}$ atoms/$cm^2$ | 23.729 |
| | $5x10^{17}$ atom/$cm^2$ | 27.566 |

A programme of industrial trials of ion implanted PCB drill has commenced in collaboration with a domestic industrial partner. Field tests of ion implanted PCB drills were carried out by the domestic industrial partner. This company specializes in computer-controlled drilling and cutting out of printed circuit boards. On the drilling, tow and six circuit boards for 0.15, 0.3 mm in diameter and 0.4t are stacked one above the other. Ten implanted drills were tested. Results are shown in Figure 5. PCB drills were implanted and acquired 1.5~2 times larger durability than those non-irradiated.



(a) Initial (b) 3000 Hits

(c) 3000 Hits (d) 5000 Hits



(e) 5000 Hits

Figure 5: The shape of drill after field test .
(a) Unimplanted, no field test , (b) unimplanted, 3000 hits, (c) 120 keV, 5 x $10^{17}$ atoms/$cm^2$, 3000 hits, (d) unimplanted, 5000 hits, (e) 120 keV, 5 $10^{17}$ atoms /$cm^2$, 5000 hits

## CONCLUSION

1. The result of the work show that the effects of implantation can be related to any change in mechanical properties.
2. Nitrogen ion implantation can increase the surface hardness of WC-Co. A suitable implantation dose is in the range of 2.0 x $10^{17}$~ $5x10^{17}$ atoms/$cm^2$. An excess does causes a decrease in surface hardness of WC-Co.
3. In field test the limits of the PCB drill bits is increased from 2000 to 3000.

## REFERENCES

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