The changes for mechanical properties of nitrogen ion implanted micro drill

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1. Introduction

Cobalt cemented tungsten carbide(WC-Co) are used in a variety of important industrial components and parts, such as cutting tools, milling tools, mechanical face seals, drills, punches, submersible pumps, and so on[1]. In recent years, PCB micro drills tend to be more minimized increasingly as the electronics components have been more highly accumulated and minimized. Coating processing such CVD and PVD for cutting tools is caused alteration of tool shape and dimensions as well as abruption of intermixing between the bulk and the treated layer. Therefore such coating processing is inadequate method which is applied to the surface treatment of the precision mechanical parts with submicrometer tolerances. But ion implantation is a surface modification technology in which atoms or molecules are ionized, accelerated to tens or hundreds keV of energies, and then implanted to the target materials. Nitrogen implantation in metals and metallic alloys generally improves surface properties, with the objectives of ensuring a low friction coefficient or surface hardening and producing protective or anticorrosion coatings as well as no influence on surface finish, tool shape and dimension although shallow implanted depth[2]. This article reports the study of the changes for mechanical properties of nitrogen ion implanted micro drill

2. Methods and Results

2.1 Test Methods

The simplest and most economical process for the strengthening of metallic surfaces is by the ion implantation of nitrogen which, being an elemental gas does not require mass analysis due to beam current and equipment price. But for this application, the inevitable mixture of molecular, atomic and some fast neutral species in the extracted beam is acceptable, and enables the full output of the ion source to utilized[3]. Therefore, it consists of a DuoPIGatron ion source[4], vacuum system, diagnostic system, power supply, an accelerator tube, target chamber and target cooling system.

Nitrogen ions are generated using by duopigatron ion sources up to 10mA, 40 keV and accelerated up to 120 keV. The cleaned the WC-Co PCB micro drill samples with ultrasonic cleaner was implanted with nitrogen ion at the energy of 90, 120 keV, beam intensity of 10μA/㎠, and with doses of $1x10^{17}$, $5x10^{17}$ions/㎠. The typical beam profile is measured by a linear scanning system based on a Faraday cup with 5 mm diameter. Depth profile of the implanted N in Si was calculated by the simulation program of the transport of ions in matter (TRIM ver.95) code [5]. To obtain the hardness (H) of nitrogen ion implanted layer, not including the surface influence, a nanoindenter (Nano indenter XP developed by MTS) was used. On the drilling, four circuit boards (0.1t for 0.105 mm drill bit) are stacked one above the other for field test of PCB respectively. One bit drilled 10000 holes. The rate of rotation is 300 krpm for 0.105 mm PCB micro drills

2.2 Trim code

Fig. 1 shows depth profile of implanted N in WC target calculated by TRIM code [5]. Calculation is performed on 120 keV N^+ and N_2^+ ions.

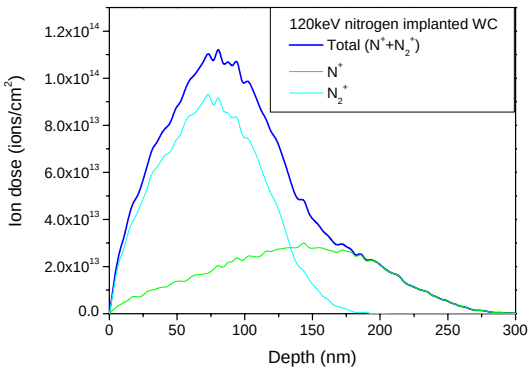

Fig. 1. Depth profile of the implanted N ions in the WC substrate calculated by TRIM code (ver. 95.06).

2.3 Surface Hardness

In Fig. 3(a), the result as a function of dose and energy shows that the most of the micro-harnesses are improved than that of unimplanted. The hardness improvement is due to the high concentration of nitrogen in the implanted region at depths between 25 and 150 nm below the surface as shown in Fig.1.

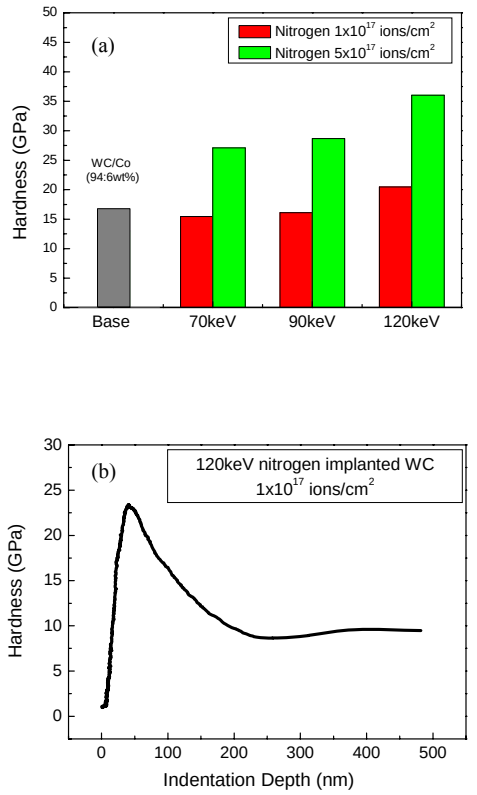

Fig. 2. The results of hardness
(a) Function of dose and energy
(b) Hardness depth profiles

2.4 Drilling test

Figure3. show the Process Capability(Cpk) by the number of drilling times. Cpk is an index (a simple number) which measures how close a process is running to its specification limits, relative to the natural variability of the process. The larger the index, the less likely it is that any item will be outside the specs.

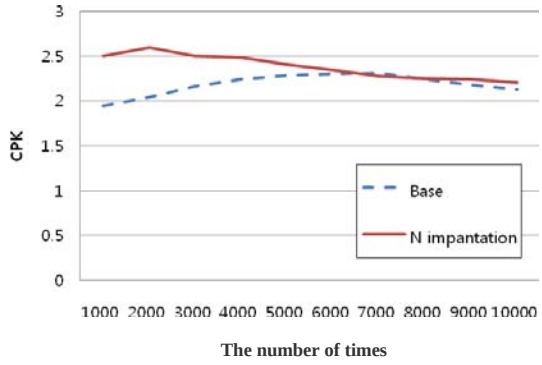

Fig. 3. The process capability of drilling .

As the number of drilling time increases, the process capability(Cpk) lowers. The process capability rapidly decreased at drilling of 5000 times and it's been similar to process capability of un-implanted micro drill. This could be attributed to small implanted depth below 250nm, as shown in Fig.1, 2(b)

3. Conclusions

Nitrogen ion implantation can increase the surface hardness of micro drills. The implanted depth is vary sallow, enhancement effect of durability or life time are limited. The enhancement of implantation depth is required to practical applications.

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