The study of high speed micro-drilling performance and machining quality of coated micro-drills with Zr-C:H coatings

W.H. Kao1, Y.L. Su2, S.H. Yao3, S. H. Liu1

1 Institute of Mechatronoptic Systems, Chienkuo Technology University, Changhua, Taiwan
2 Department of Mechanical Engineering, National Cheng Kung University, Tainan, Taiwan
3 Chang Jung Christian University, Tainan, Taiwan

n18851158@yahoo.com.tw (W.H. Kao)

Introduction

A closed field unbalanced magnetron (CFUBM) sputtering system is used to deposit Zr-C:H coatings with various C2H2 flow rate on micro-drills (a diameter of 0.2 mm). The drilling performance of the coated micro-drills is evaluated by conducting high-speed through-hole drilling tests using printed circuit board (PCB) specimens. The service life of the coated micro-drills is assessed utilizing two different criteria, namely the nail head ratio and surface roughness of the drilled hole, respectively. Overall, the results show that the 5 sccm C2H2 flow rate coating has the optimal high-speed machining performance, i.e. it extends the tool life by a factor of at least three (6000 hole) compared to the uncoated micro-drill and yields a significant improvement in the machining quality.

Experimental Procedures

A Zr intermediate layer of thickness 0.1 μm was then deposited on each substrate. Subsequently, a Zr-C layer was deposited on the Zr film. Finally, Zr-C:H topcoats were deposited on the Zr-C layers, which operated C2H2 flow rate ranging from 3 sccm to 6 sccm. The drilling operation was performed using a commercial machining center (W1686-10, Schmol-Mashinen, Germany) with a drilling speed of 160000 rpm (100.5 m/min) and a feed rate of 1.4 m/min (0.00875 mm/rev). The service lives of the coated micro-drills were evaluated using two different criteria: (1) a nail head ratio greater than 1.5 (see Figure 1); (2) a drilled hole surface roughness (i.e. maximum peak-to-valley depth) greater than 25.4 μm.

Results and Discussion

The Zr-C:H-3 (C2H2 flow rate 3 sccm) coating has a high hardness (42 Gpa). Adopting a service life criterion of a nail head ratio of 1.5, the Zr-C:H-5 (C2H2 flow rate 5 sccm) coating possesses the optimal high-speed machining performance, which yields a micro-drill lifetime above 6000 drilled holes. It represents above three-fold improvement on that of an uncoated micro-drill and it also improves machining quality.

Fig.1 illustrates the variation of the surface roughness of the drilled holes

Fig.2 illustrates the variation of the surface roughness of the drilled holes

Fig. 3. Typical nail head ratio characteristics of 6000th hole drilled using Zr-C:H-5 coated micro-drill.

Fig.4. Typical damage around 6000th holes machined using Zr-C:H-5 coated micro-drill.