Mechanical processing of IMS

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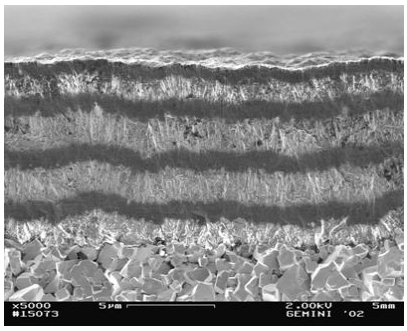
GCT GmbH in Weingarten is a worldwide leading manufacturer of diamond coated tools for the mechanical processing of printed circuits boards.

The LED-technique is a cutting-edge technology which has revolutionized the illuminating market for years. This technology is also increasingly implemented in the automotive industry, e.g. with rear lights. Particularly with LEDs a good heat management leads to a higher power output and lifetime. For an efficient heat removal IMS (Insulated Metallic Substrate) is being used i.e. printed circuits board with isolated metal substrate. As metal carrier mostly aluminum with a thickness between 1.0 and 3.0 mm is being used; more seldom is copper with a thickness between 1.0 and 1.50 mm. FR4 prepreg or ceramic layers are used as dielectric fluid.

The manufacturing process of IMS is a challenge for all production departments. Special tool geometries are ideally adopted for drilling and routing metal carriers. The optimization of process parameters requires a lot of experience. In addition, the machines have to fulfill certain requirements, e.g. marginal vibrations and collet run-out. Minimal quantity lubrication is perfectly suited for routing.

Since the beginning of last year diamond coated drills and routers have been used very successfully in the mechanical processing of IMS. This was only possible through the combination of a special multilayer diamond coating (picture 1) and adapted tool geometries.

The following advantages justify the successful application of diamond coated tools:
- diamond hardness of 10.000 HV0.05
- tool life increases by factor 10 due to minimal cutting edge abrasion while drilling and routing
- very good chip removal due to the low friction coefficient of diamond
- very low tendency to formation of a built up edge
- very high drilling and routing accuracy because of optimal spiral lengths of diamond coated standard tools



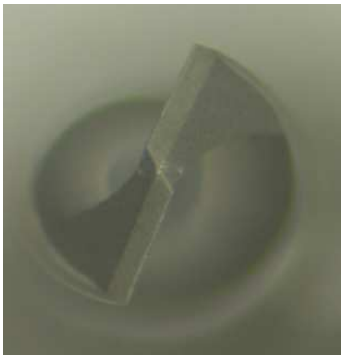
Picture 1: multilayer diamond coating (picture of CemeCon AG)

Actual applications:

1. Drilling

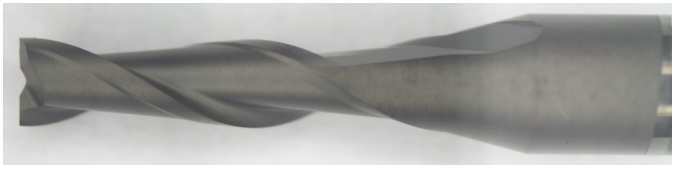
When processing IMS diamond coated drills are being used in the diameter range of 0.60 - 6.40 mm. The recommended cutting speed is v = 250 m/min ± 10 %; the chip load should be approx. 50 - 60 % compared to FR4. The tool life of diamond coated drills compared to uncoated drills increases min. by factor 10. Standard drills in the diameter range ≥ 3.20 mm have cylindrical outer diameters which result in very high cutting forces and frictional heat development. The diamond coated drills have a special geometry with back-tapered outer diameter and web thinning. This geometry with very short dead center enables you to drill with Ø 4.0 mm even without pre-drilling.
Depending on the quality requirement and aluminum quality drills with diameter > 1.50 mm can partly be used for drilling 2 panels per stack.

Application:
- tool: diamond coated drill type 1 638 (picture 2)
- diameter: 0.95 mm
- spiral length: 7.00 mm
- material: aluminum Al Mg3; 1.50 mm thick
- entry material: phenolic paper; 0.50 mm thick
- spindle speed: 80000 rpm
- feed rate: 3.20 m/min
- retract: 10.0 m/min
- tool life: 7000 hits

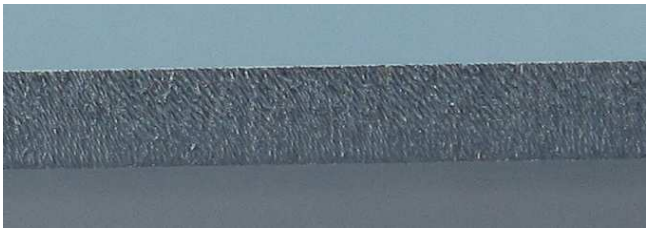
Picture 2: diamond coated drill after 7000 hits 

2. Routing

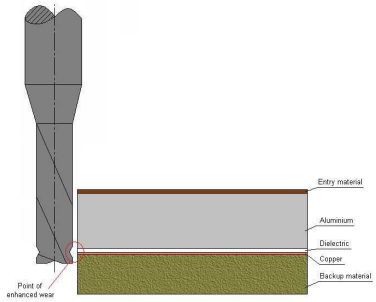
2-flute end mills with diamond coating (picture 3) are most suitable for routing of IMS outer and inner contours. Due to the physical surface slip of the diamond coating the chip removal is very good and there is no remarkably built up edge.
The recommended cutting speed is v = 230 m/min ± 10 %; the XY-feed rate is comparable to FR4. The tool life of diamond coated end mills in comparison to uncoated tools is approx. 10 times higher. IMS should be routed in 2 passes with diameter compensation.

Picture 3: diamond coated 2-flute end mill 

Application:
- tool: diamond coated 2-flute end mill type 1 322
- diameter: 2.00 mm
- spiral length: 6.00 mm
- routing machine: with vacuum table and air bearing spindle W 1750-02 (10-160000 rpm)
- lubrication: minimal quantity lubrication
- material: aluminum Al Mg3; 1.50 mm thick
- entry material: phenolic paper; 0.50 mm thick
- entry position: pre-drilled with same drill-Ø
- spindle speed: 34000 rpm
- feed rate: 1.00 m/min
- routing: in 2 passes with 200 µm diameter compensation
- tool life: > 80 m depending on the required quality (picture 4)

Picture 4: surface after approx. 60 m tool life 

IMS with ceramic dielectric is needed more and more often. Thereby the tool life is reduced drastically due to the ceramic layer (picture 5).



Picture 5: increased tool wear caused through the ceramic layer

Depending on required quality and backup thickness re-setting of the router tip height increases tool life.

Recommendation:
After approx. 50 % of the tool life re-setting of the router tip height can be done. If the ceramic dielectric is on top the tip height has to be reduced. The height changing depends on the thickness of the ceramic layer and the outer layer thickness. Depending on the thickness of the backup board this can be multiple repeated.

Summary:

- The costs of mechanical processing of IMS are primarily affected by the appropriate choice of tools and parameter. Diamond coated drills and end mills assure a high dimensional accuracy and process capability and are used globally in the meantime. In particular the diamond coated tools have become widely accepted with the mechanical processing of IMS as well as with printed circuits boards' materials with fillers.
- From the technical view particularly collet run-out and vibrations have a high impact on tool life and surface quality.
- Tool life and quality are positive affected by using of a minimal quantity lubrication unit.
- With ceramic dielectrics the recommended spindle speeds have to be reduced by 20 %. The tool life will be reduced approx. to half in comparison to FR4 dielectrics.