CUSTOMER CASE STUDY

L-Edit tackles MEMS packaging challenges

Micro-electromechanical systems (MEMS) represent a highly cost-effective way of building tiny sensors and actuators. But a major problem with MEMS devices is that they need to be hermetically sealed: a level of protection much higher than that generally used for integrated-circuit packaging. As they can measure as little as 1mm on a side, handling MEMS devices is extremely difficult and the use of conventional packaging techniques can damage the delicate MEMS structures. The alternative is to perform packaging at the wafer level.

Hymite is a specialist that has developed a way of providing hermetically sealed packages for optical and MEMS devices that is both cost-effective and prevents damage to the components. Not only that, the company

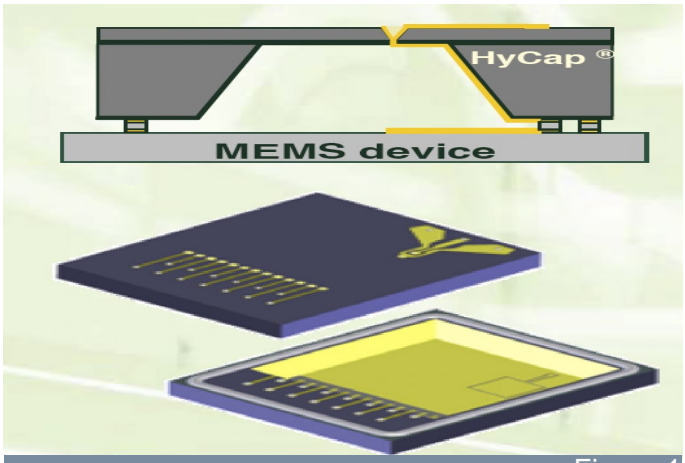

Figure 1

has built a novel design-automation flow that takes full advantage of both 3D solid-modelling tools and the L-Edit layout design software from Tanner Research.

HyCap® is one example of Hymite's work and provides a chip-sized hermetic seal cap for MEMS devices. The company uses the same silicon micro-machining techniques as those used in the underlying component to create an array of caps at the wafer level. Etching and electroplating processes are used to create vertical electrical feed-throughs that can operate with very low losses at frequencies up to 40GHz. To define the caps, Hymite needs to make use of double-sided lithography so that holes can be etched through the caps to provide the electrical connections and to define a headroom cavity for the MEMS device. This demands high accuracy in matching the various masks that are used to define the micro-machined structures and the metallization layers that carry electrical signals to the MEMS components.

The first step taken by Hymite is to model the cap in 3D using the SolidWorks software. Andreas Hase, MEMS product manager at Hymite, said: "We start with a 3D model so we can get a good impression of what is going and how the components fit together."

Using the 3D model, the designers at Hymite can accurately match the cap to the MEMS device that will sit underneath and define the through-holes that will be etched from both sides of the wafer without having to work with the mirror images that they would need with a set of hand-made 2D representations. The next step converts the 3D design into a set of 2D layers that will ultimately be used to create the various lithographic masks. All features in the 3D modelling are defined on planar sketches that directly become a layer in L-Edit. " This process gives our customers confidence in the design and enables a remarkable short transfer from design into prototype." said Hase.

Hymite has made extensive use of the T-cell macros in L-Edit to tune its workflow and streamline the process of creating masks from layers that have been defined using the more intuitive 3D model. "We use T-cells to apply process-technology parameters where we may need to enlarge or shrink lines for micromachining process reasons," said Hase.

Hase said the company has invested a lot of time in building and updating the T-cells to make sure the process is as streamlined as possible. The company does not just use the T-cell macros to convert layouts from the 3D package, but to number all of the thousands of caps that will be built by the mask set and even to create special shapes that are entered directly onto the mask layers in L-Edit.

"The T-cells definitely save a lot of time. There is a lot of functionality that you can define in the C code," said Hase, adding that the use of T-cells allows more than just time savings. "We use T-cells to add alignment and dicing marks as well as the numbering for each of the dice. With up to 6000 devices on a wafer, that is something we could not do manually. It really is an enabler to do that numbering automatically."

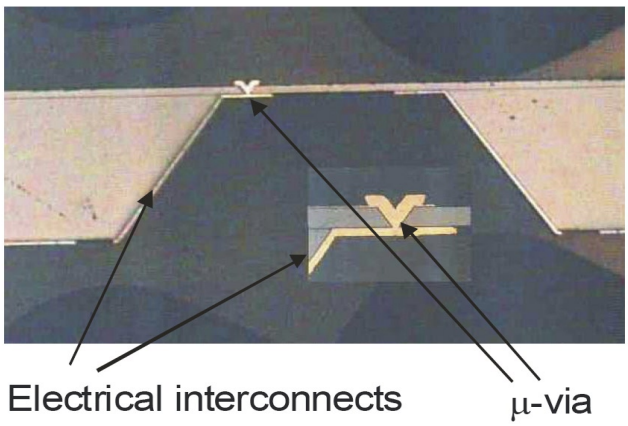

Figure 2

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L-Edit has been in use at Hymite from the start of the company, which was founded in 2001 by Matthias Heschel and Jochen Kuhmann. The layout tool was used extensively at the Danchip national laboratory in Denmark. It was research at Danchip that led to the creation of Hymite. “We decided to continue using L-Edit at our company,” said Matthias Heschel, VP Engineering of Hymite. He said the technical support from Tanner and EDA Solutions has been excellent in providing solutions to design challenges. With six people now working on the design of optical and MEMS solutions at Hymite, L-Edit is used extensively to support its novel approach to hermetic package design and construction.

Technical apps piece:
T-cells streamline MEMS package design

The macro-programming environment in Tanner EDA’s L-Edit tool offers a powerful way of automating design processes and has found many uses in the MEMS arena, particularly with the creation and manipulation of unusual shapes and exotic manufacturing techniques, such as double-sided lithography.

A challenge with MEMS devices is that they need to be hermetically sealed. Although there are hermetic packages on the market for conventional ICs, they run into problems with MEMS components. As they can measure as little as 1mm on a side, handling MEMS devices is extremely difficult, which increases the packaging cost and risk of yield loss. The alternative is to perform packaging at the wafer level but the use of conventional packaging techniques can damage the delicate MEMS structures.

Hymite is a specialist that has developed a way of providing hermetically sealed packages for optical and MEMS devices that is both cost-effective and prevents damage to the components. Not only that, the company has built a novel design-automation flow that takes full advantage of both 3D solid-modelling tools and the L-Edit layout design software from Tanner EDA.

Hymite’s approach to providing hermetically sealed packages is to use wafer-level packaging that is made using the same silicon micro-machining techniques as those used for the actual MEMS components. Figure X [Hymite 2] shows a silicon cap made by the company for use in wafer-level packaging. It shows a cavity etched into the silicon and an electroplated solder sealing ring and contact metallization for hermetic sealing. Vertical micro-vias providing the connection between a metal layer deposited inside the cavity and the outer SMT bond pads. The micro-vias are hermetically sealed by electroplated gold metallization. A schematic of the HyCap® and the use of coplanar RF line metallization is shown in Figure Y [Hymite 1]

To define this structure, Hymite needs to define several IC fabrication masks that will be used on either side of the silicon as the company uses double-sided lithography and wafer processing to allow the feed-through holes to be made. The wet-etch processes and metallization used create electrical feed-throughs that can operate with very low losses at frequencies up to 40GHz. During assembly, a wafer full of silicon caps is placed on the wafer containing the MEMS devices. The device is sealed using eutectic gold-tin solder, which has excellent wetting properties in a flux-free flip-chip soldering environment. A high melting temperature of 278°C ensures integrity of the seal during further surface-mount technology processing.

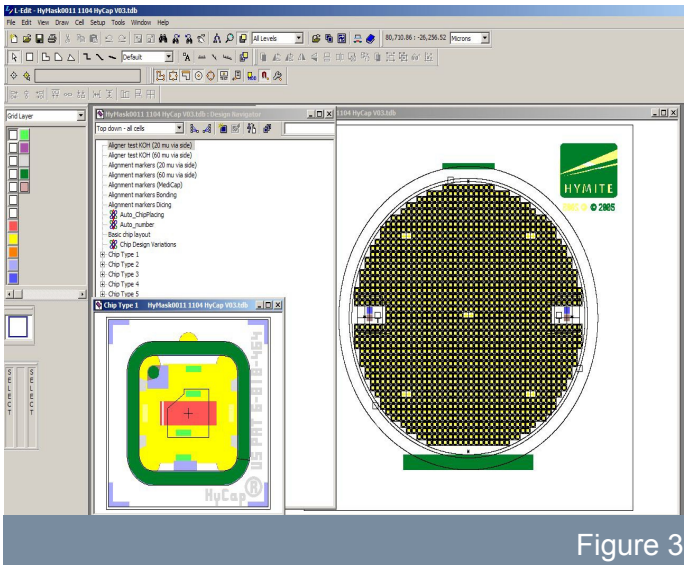

Figure 3

To produce the masks, Hymite starts with a 3D model of the hermetic package. The company works in 3D rather than trying to draw 2D masks directly as its approach reduces errors and allows easier visualisation of the complete, assembled system. Once the design of the package has been completed in 3D models, the next step is to create a set of IC fabrication masks. The designers define features on 2D sketches that cut through the 3D model. These planes will ultimately become the layer masks that are processed using L-Edit.

T-cells have been written by Hymite that take the features defined in the 3D model and then applies a number of modifications, such as widening or narrowing lines to meet the process requirements. By using automatic transformations from sketches that intersect the 3D model at different levels, it is easy for Hymite’s designers to create the mirror-image masks needed for back-side wafer etching and metallization. Other T-cells written by company apply per-package numbering to the 6000 individual caps that a 6inch wafer can contain. Without the use of macros, the manual manipulations needed would seriously stretch the resources of the design team and increase lead times. By combining L-Edit and its powerful C-based macro-programming environment with the ease of use of a 3D package such as SolidWorks, Hymite has streamlined the task of creating low-cost, high-reliability packages for the MEMS industry.