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# Membrane-Templated Flexible Semiconductor Package

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***Abstract***— *Membrane-templated deformable carrier and elastomeric encapsulant enable flexible semiconductor package in support of the demands of wearables and flexible electronic gadgets. The selectively pore-filled membrane, with metal particle suspension, is mechanically reinforced by a thin elastomeric material layer to protect the newly formed leads, and to give structure to withstand package assembly. Package assembly is achieved by attaching a silicon die via a die attach process, electrically connecting the silicon to the carrier via wirebonding, and encapsulating the package using an elastomeric material via elastomeric molding process. The elastomeric support is then peeled off, exposing the terminal surface of the leads. The deformable carrier and the elastomeric encapsulant ensure package flexibility and conformity to distortion*

***Keywords***— *Flexible, deformable, metal particle, elastomer, wearable.*

## I. Introduction

Wearable electronics require flexible materials and ultrathin packages able to withstand multi-axes distortion. The use of conventional materials, like thick carriers and stiff thermoplastics, limit the success of producing highly conformable packages. New materials and innovative processes are necessary to realize the industry shift towards flexible semiconductor packages and electronic devices.

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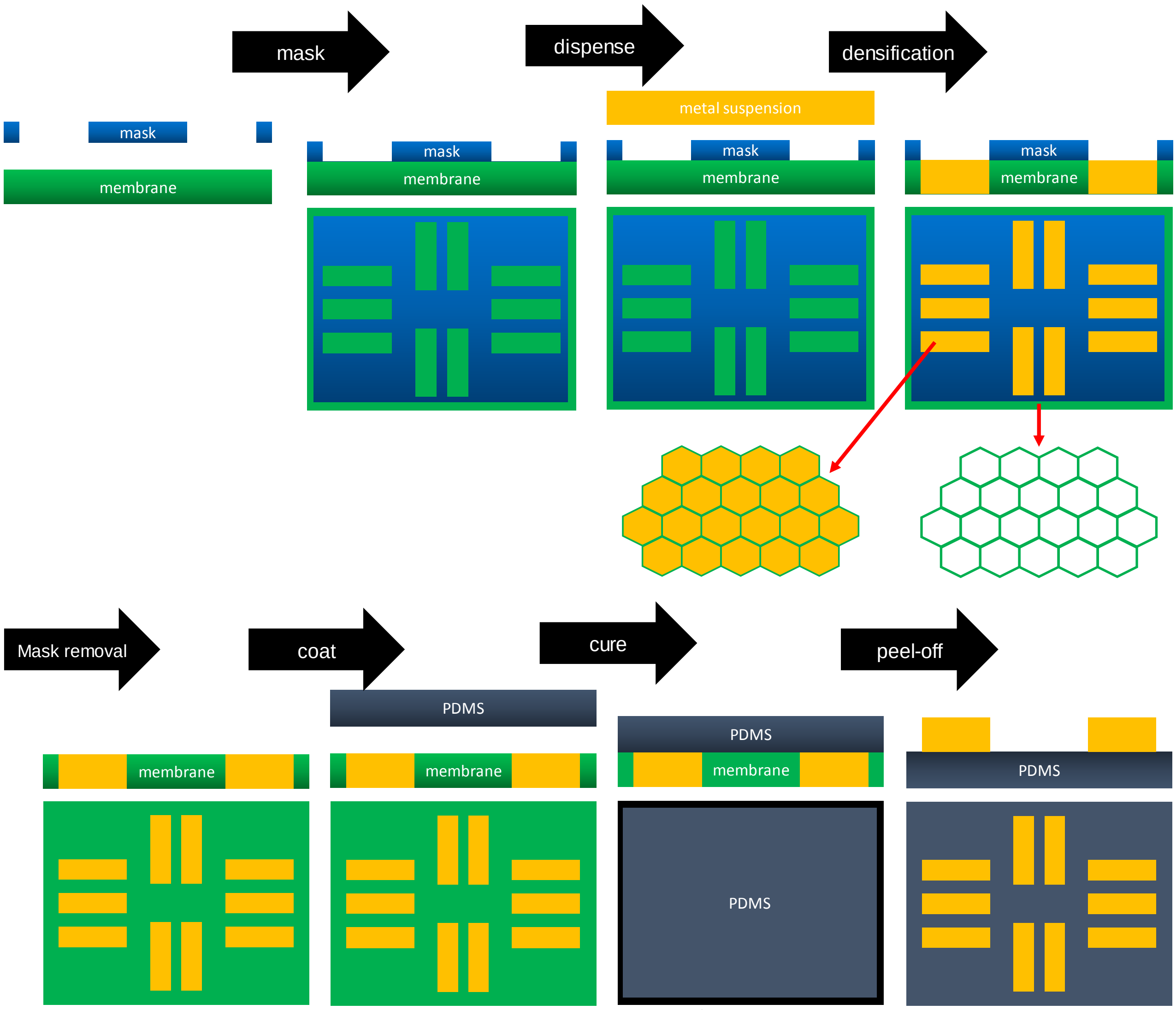


Fig. 1. Carrier assembly process flow.

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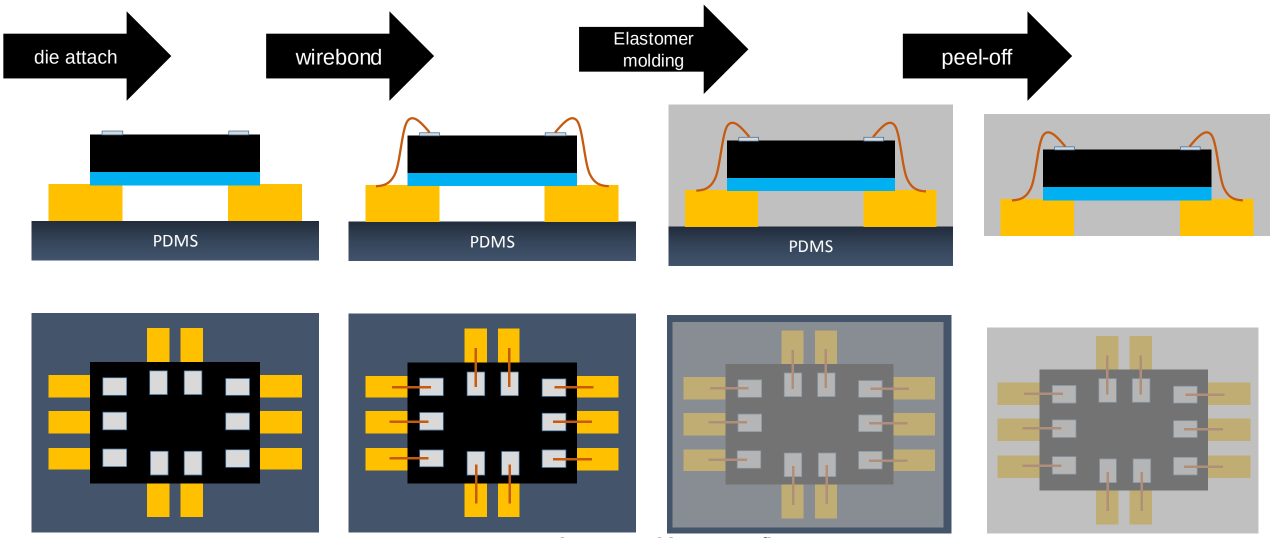

Fig. 2. Package assembly process flow.

Conventional semiconductor packages are assembled with a set of materials and processes resulting in products with minimal tolerance to distortion and bending. Delamination is a common failure mode encountered when conventional packages are subjected to distortion and bending. This failure mode can lead to package failure at time zero and during field application. To address the demands of wearable electronics and foldable display/devices, ultrathin conventional packages are assembled. The manufacturing of ultrathin packages requires a new set of materials with better tolerance to thermomechanical stresses associated with bending and distortion.

## II. Design and Process Solution

The solution assembles semiconductor packages using a deformable modified carrier and an elastomeric encapsulant. The modified carrier is built (Fig. 1) using a membrane sheet/film as template, wherein the pores are selectively filled with a conductive material from a suspension of metallic particles, forming the leads. The lead footprint is achieved using a mask. The metallic particles from the suspension, conforming to the mask pattern, are densified via suction filtration. A thin elastomeric material (*e.g.* polydimethylsiloxane) layer to protect the newly formed leads, and to give structure to withstand package assembly, mechanically reinforces the selectively pore-filled membrane. The metallic particles are fused during the curing of the elastomeric support, forming a solid wirebondable surface. The unfilled portions of the membrane is peeled off from the assembly, leaving the metallic pattern attached to the elastomeric support, completing the assembly of the deformable carrier. Package assembly (Fig. 2) is achieved by attaching a silicon die via a die attach process, electrically connecting the silicon to the carrier via wirebonding, and encapsulating the package using an elastomeric material via elastomeric molding process. The elastomeric support prevents any mechanical (scratches, chipping, *etc.*) and chemical damage (corrosion) during assembly. The elastomeric support is then peeled off, exposing the terminal surface of the leads. The deformable carrier and elastomeric encapsulant ensure package flexibility and conformation to distortion. The resulting package cross-sectional and top views are shown in Fig. 3.

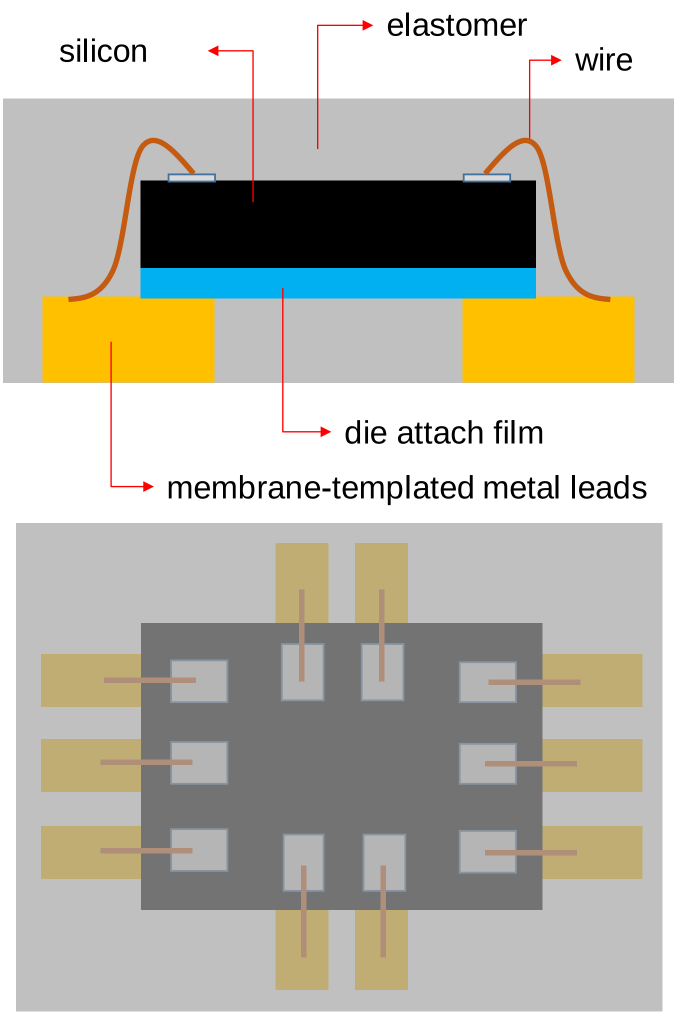

Fig. 3. Package cross-sectional (top) and top (bottom) views.



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## III. Conclusion

The novel solution enables flexible semiconductor package by using deformable membrane-templated carrier and elastomeric encapsulant. The membrane-templated carrier provides higher flexibility and conformity to distortion arising from its deformable pore structure & thin dimension. The elastomeric support prevents any mechanical (scratches, chipping, *etc.*) and/or chemical damage (corrosion) during assembly. The elastomeric encapsulant provides flexibility towards bending and distortion.

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