Fraunhofer IZM

Fraunhofer Institute for Reliability and Microintegration IZM

Electronic Packaging Days 2025

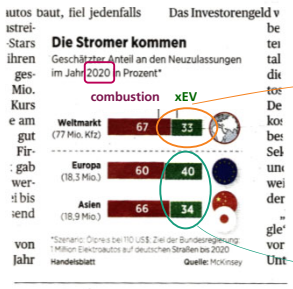
Tina Thomas

Molded Packages for Power Devices - Technologies & Specifications -

Motivation

Forecasts EV sales versus reality

Forecast 2010 → 2020



McKinsey/Handelsblatt 06/2010

Forecast 2023 → 2030

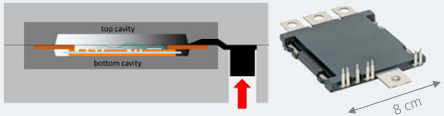
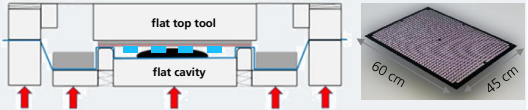
2024 - share by eco-zone

Goal was clear ……technological progress had been made…….how can power electronics packaging contribute to electrify transportation?

→ ***energy efficient & smaller devices // cost effective production = cost reduction***

Molding Technologies

Processes in General

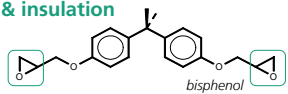
	Transfer Molding	Compression Molding
		
Main parameter	8 – 12 MPa for 1 - 2 min at 160 – 180 °C	2 - 5 MPa for 5 - 10 min at 120 – 150 °C
Encapsulant	pellets / lateral load	liquid or granular or sheet / top side load
Tool shape / size	3D / up to 8 x 8 x 1.5 cm³	plane-parallel / up to 60 x 45 cm² & height flexible up to 1 mm
Product shape / size	defined by mold cavity / identical to tool [cm³]	cuboid / defined by singulation [mm³]
Position in process sequence	end	beginning (for Fanout)
Typical components	heterogeneous assemblies	single dies / multi dies
Component fixation	clamped → multi sided exposed product surface	adhesive tape → single sided exposed product surface

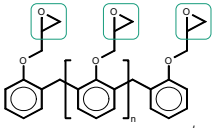
Fraunhofer IZM

Molding Technologies

Material in General

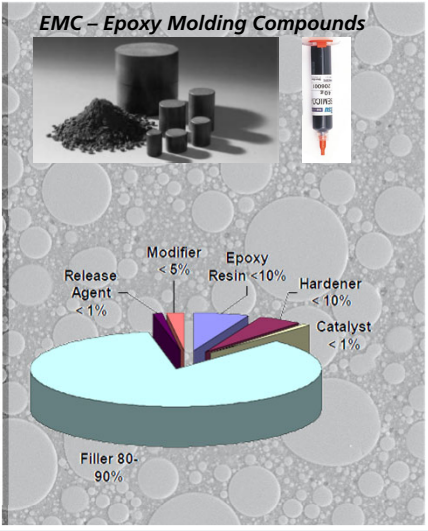
Aim: protection & insulation





Profile of Epoxies:

- Processing properties adjustable across a wide range: thin – viscous – solid
- Proven compatibility with microelectronic structures
- Good adhesion to metals, silicon, polymers and other
- Thermomechanical properties such as CTE and modulus of elasticity can be adapted to packaging requirements by
  - Filling up to 90 wt% with SiO_2
  - Adjusting the polymer network
- High media resistance
- Good high-temperature resistance, use up to 175 °C and higher is possible
- High dielectric strength

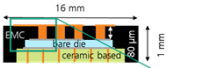


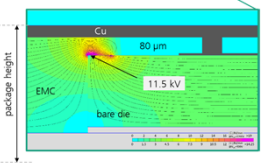
Molding Technologies

Material - Power Related Specifications (low-med power range)

Dielectrics

- **Package layout**
  - voltage = 900 V
  - distance to conductor = 80 µm





- **Result of Simulation**
  - Field E@V_ds = 11.5 kV

- **Conclusion:**
  - **Dimension**-wise: larger distance to conductor vs. miniaturization
  - **Material**-wise: corresponding dielectric strength of encapsulant needed → beware of polymer ageing

Thermal

- Thermal requirement for power encapsulant
  - T_{ave} ~ 150-175 °C
  - T_{max} ~ 220 °C (for a few seconds/overload)
- Thermal behavior f(T, t, media, E, …)
  - Instant decomposition T_{dec} ~ 300 °C
  - Degradation starts << 300 °C
  - Ageing
    - Embrittlement
    - Decrease of cohesive & adhesive strength
    - Decrease of dielectric strength

sample for 500 h at 250 °C

Example I – Direct Cooled Power Module

Package Overview

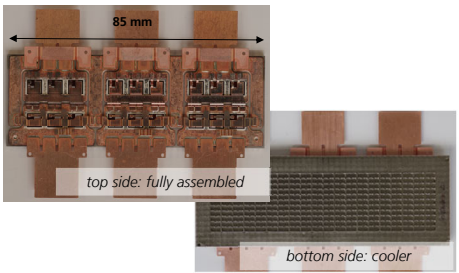
What: AMB based half-bridge power module with integrated cooler; encapsulated by EMC

What for: low inductive power application (automotive) plus miniaturize & simplify the buildup

How: assembly of SiC dies, power & signal contacts on AMB with integrated cooling structure // Transfer Molding // exposing topside

USP: substrate = carrier for circuit & act as cooler → very short thermal path

Assembly



Package

ROGERS CORPORATION

Fraunhofer IZM

Example II – Single Chip Package

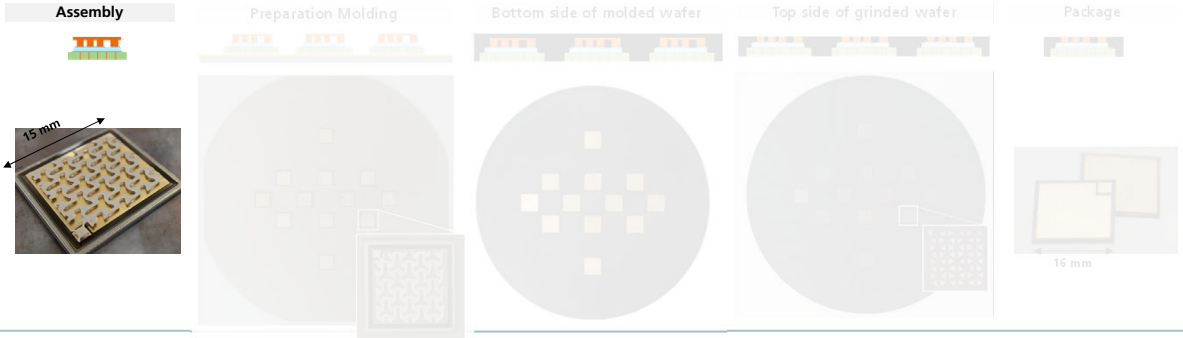
Package Overview

What: IGBT sandwiched between ceramic and Cu columns; encapsulated by EMC

What for: reliable and SMD-mountable Prepackage with enhanced thermal performance

How: sintering IGBT onto substrate // sintering Cu onto IGBT // **Compression Molding** // grinding // surface Finish // singulation

USP: one molding tool for different die size & package thickness



Example III - AC-DC-inverter

Package Overview

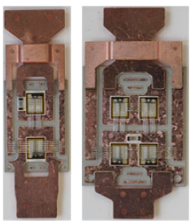
What: AMB based half-bridge power module (modular size option); vertical signal contacts; encapsulated by EMC

What for: low inductive power application (automotive) & driving Compression Molding to higher thickness

How: assembly of SiC dies, power & signal contacts on AMB // **Compression Molding** // grinding & surface metallization // singulation

USP: power scalability & modularizable module design to ease processing & enable one molding tool for different sizes

Assembly + Compression Molding + Exposing Topside = Packages



2-die-module 4-die-module

Fraunhofer IZM

Fraunhofer Institute for Reliability and Microintegration IZM

Thank you for your attention

Fraunhofer IZM

Fraunhofer Institute for Reliability and Microintegration IZM

Contact

Tina Thomas & Karl-Friedrich Becker
SIIT-AET
+49 30 46403 -625 (TT) / -242 (KFB)
tina.thomas@izm.fraunhofer.de / karl-friedrich.becker@izm.fraunhofer.de

Fraunhofer IZM
Gustav-Meyer-Allee 25
13355 Berlin
Germany
www.izm.fraunhofer.de