HIGH PERFORMANCE LIGHTWEIGHT CERAMIC MATERIAL FOR THERMAL MANAGEMENT IN ELECTRONIC DEVICES

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Outline

- Momentive Technologies Company Overview
- Hexagonal Boron Nitride (h-BN) Technology Introduction
- Application Examples of h-BN Thermal Management Solution
- Application Summary

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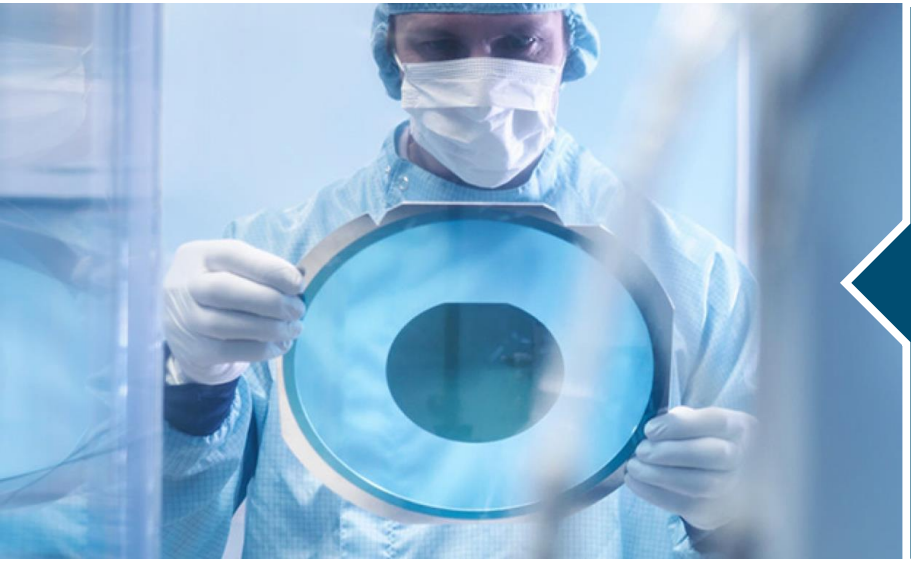
Advanced materials experts



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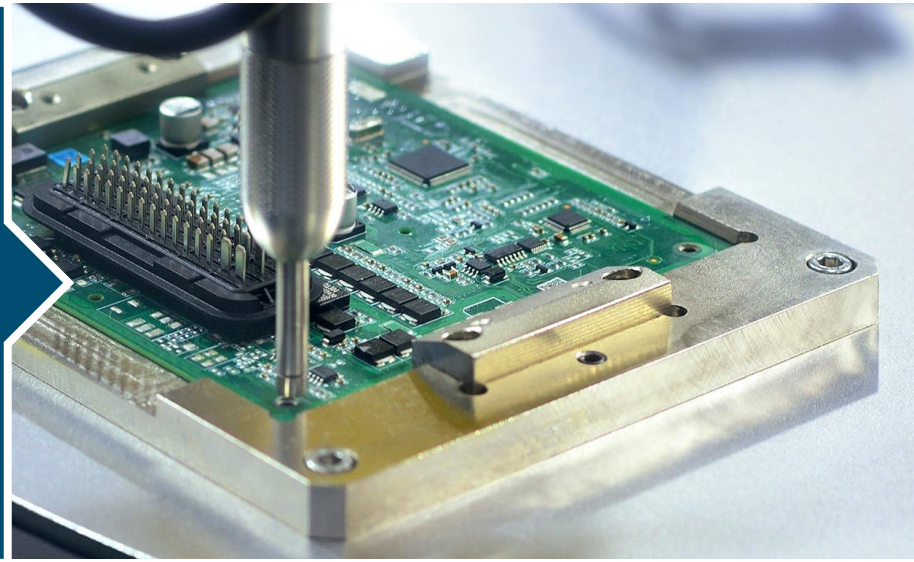

We are an **Advanced Material Company** engaged in the design and manufacture of ultra-high-performance **Quartz** and **Ceramic** products. Momentive Technologies enables high-quality processing and production in a wide range of applications in the semiconductor, aerospace, water purification, pharmaceutical, consumer electronic and telecommunication industries.

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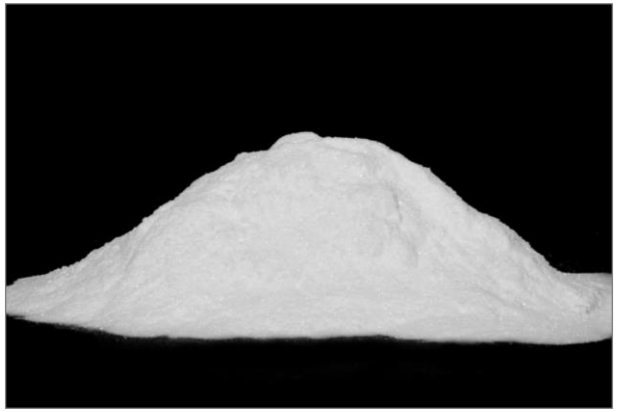
Ceramics Portfolio



POWDERS

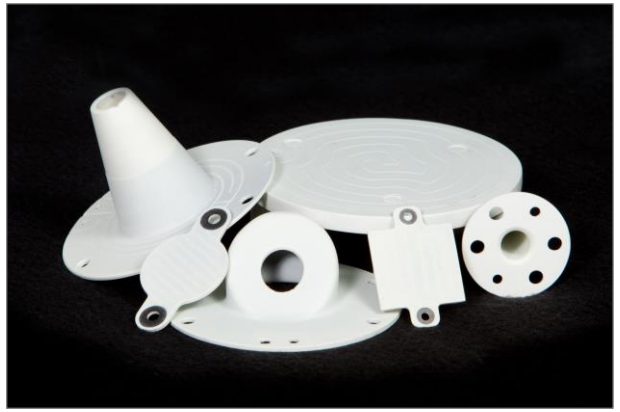
- Boron Nitride
- Boron Nitride-Based Paint
- Titanium Diboride

PRESSED & SINTERED SOLIDS

- Hot-Pressed Boron Nitride Shapes

CVD COATINGS

- Tantalum Carbide
- Pyrolytic Boron Nitride
- Pyrolytic Graphite



HEATERS & ELECTRO-STATIC CHUCKS

- Pyrolytic Boron Nitride
- Assemblies

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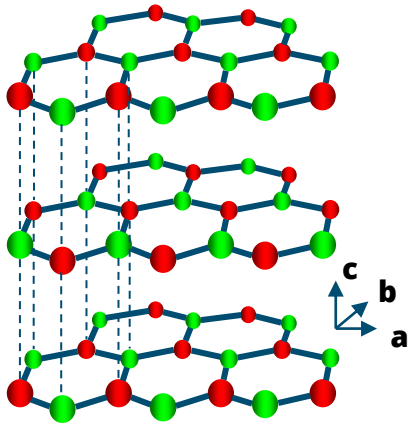
Boron Nitride Powders are High Performance Lightweight Additives

Crystal Structure of Hexagonal Boron Nitride (h-BN)



Key Features and Typical Benefits

- **High thermal conductivity**
- **High electrical resistivity**
- **High thermal stability**
- **Low dielectric constant**

Typical properties of Hexagonal Boron Nitride (h-BN)

Property	Typical Value*
Theoretical density	2.25 g/cc
Thermal conductivity	300 W/mK†
Volume resistivity	10^{15} Ω-cm
Dielectric constant	~4.0
Mohs hardness	~1.5

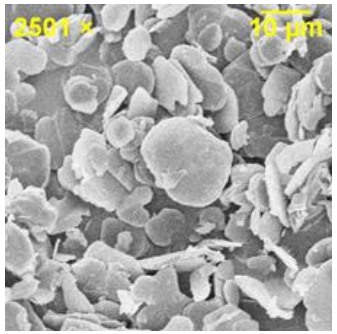
*Typical properties are average data and are not to be used as or to develop specifications.
†In-plane conductivity in the a-b plane of the crystal

Broad Diversity in Momentive Technologies (MT) h-BN Powders Portfolio

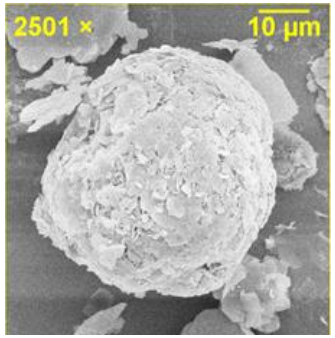
Property	Typical Value
Oxygen (purity)	0.1 – 3.0 wt%
Crystal size	0.2 – 50 μm
Particle size	0.5 – 350 μm
Surface Area	0.5 – 50 m^2/g
Tap density	0.1 – 1.0 g/cc

*Typical value ranges are covered by over 60 commercially available grades .

Single-Crystal Platelet



Spherical Agglomerate



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BN versus Competing Fillers

	BN	AlN	Al_2O_3	SiO_2	ZnO
Thermal Properties					
Thermal Conductivity (W/m-K)	**300+ †**	**260**	30	1.4	54
Specific Heat (J/kg-K @ 25°C)	794	734	798	689	**523**
Theoretical Density (g/cc)	**2.25**	3.26	3.98	**2.20**	5.64
Electrical Properties					
Dielectric Constant	**3.9**	8.8	9.7	**3.8**	9.9
Volume Resistivity (ohm-cm)	**10^{15}**	**10^{14}**	**10^{14}**	**10^{14}**	10^{7}
Mechanical Properties					
Coefficient of Expansion (ppm/K)	**<1**	4.4	6.7	**0.5**	**0.7**
Young's Modulus (GPa)	**40**	400	340	72	**12**
Knoop Hardness (kg/mm^2)	**11**	1200	1500	500	387
Mohs Hardness	**< 2**	>7	>9	~6.5	4.5

Test data. Actual results may vary.

† In a-b plane; directionally averaged thermal conductivity is sometimes reported as 55 W/m-K
Values shown are approximations based on available data and may vary from actual performance depending on variables in composition, etc.
As such, these values should be considered rough guidelines only.

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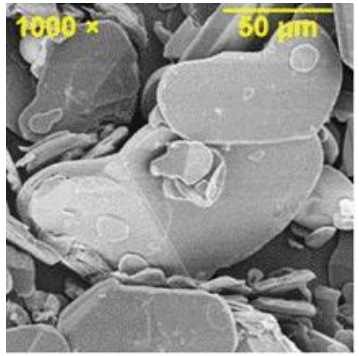
Anisotropy: Plate Vs. Sphere

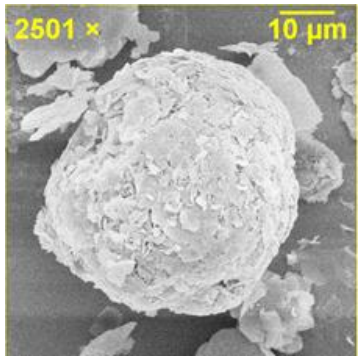
Test Conditions:

- Silicone elastomer (RTV615)
- 40 vol. % loading (59.3 wt%)
- Thermal conductivity on Netzsch LFA447

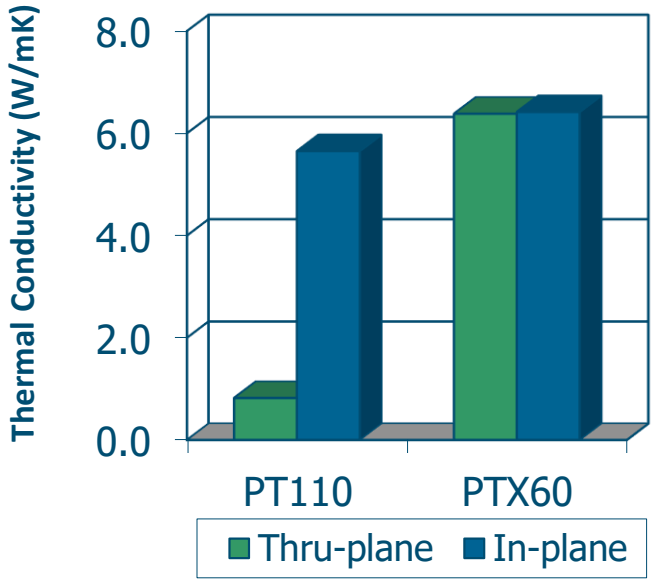
Spherical BN powder grades deliver high & isotropic thermal conductivity.



PT110



PTX60



Test data and results. Actual results may vary.

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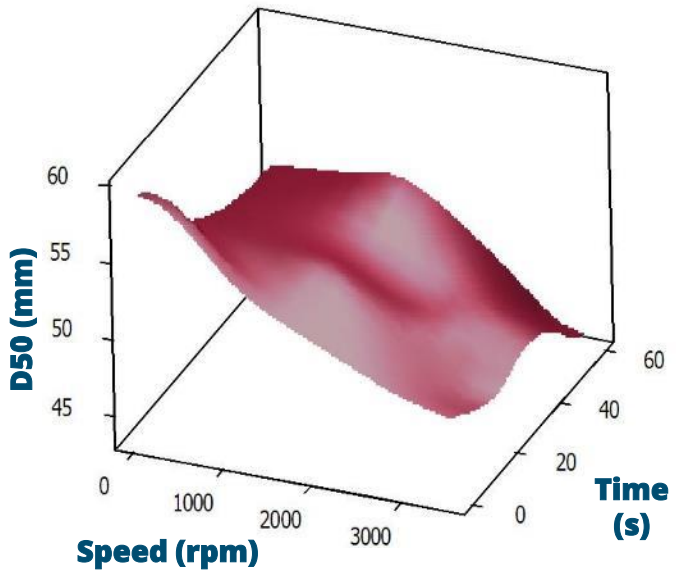
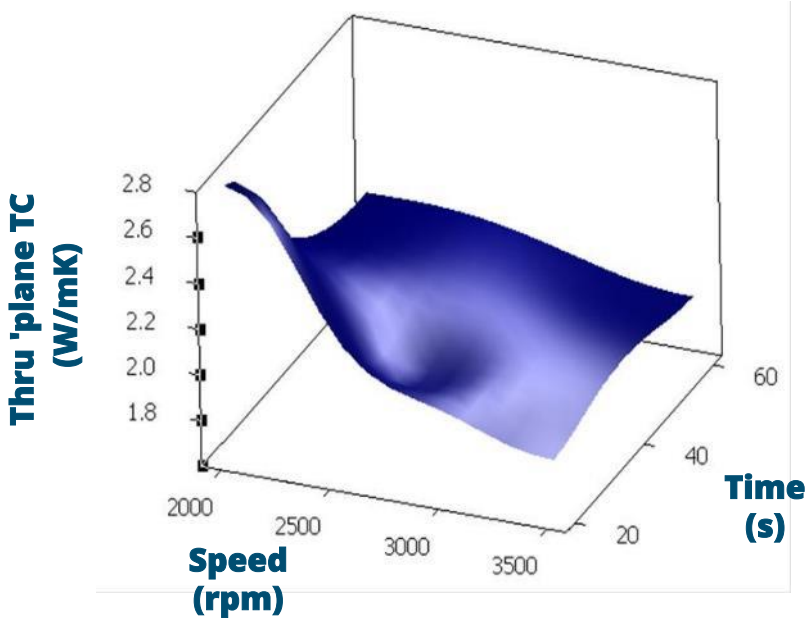
Impact of Processing Conditions on Thermal Performance

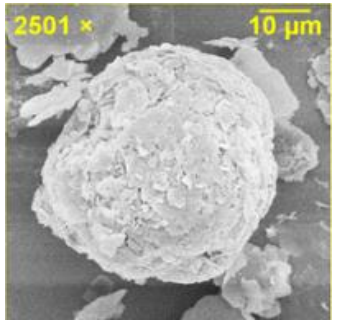
Effect of mixing speed & time on PTX60 particle size and BN-polymer composite thermal performance





Test data and results. Actual results may vary.

PTX60 spherical BN



Initial agglomerate size ~60 mm

Agglomerate breakdown lowered thermal conductivity

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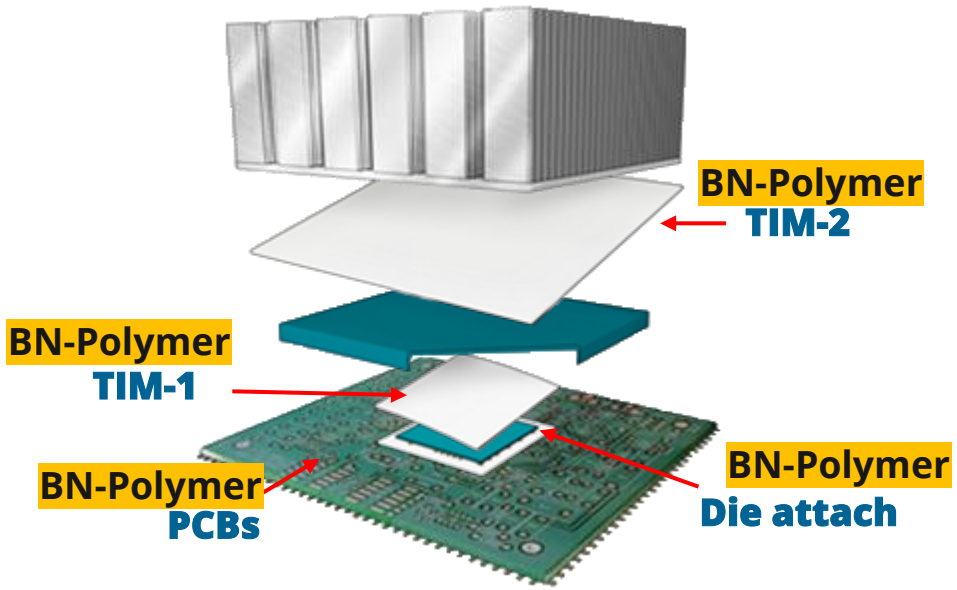
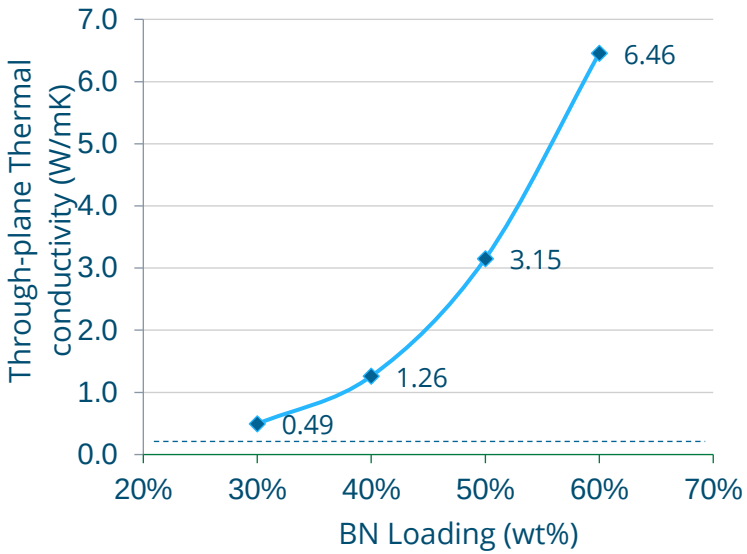
Application Example –Thermally Conductive Electrically Insulative Thermal Interface Materials (TIM)





Test data. Actual results may vary.

Typical TIMs using BN as thermal fillers:

- Thermal gels
- Gap pads
- Gap filler
- Thermal greases
- Thermal adhesives
- Thermal tapes, sheets
- Potting compounds/encapsulants
- Thermal laminates/films
- Die attach materials

Broadly used in almost all types of TIMs for thermal management in electronic packaging

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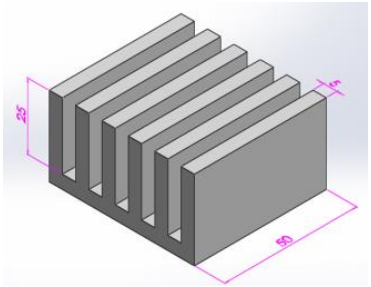
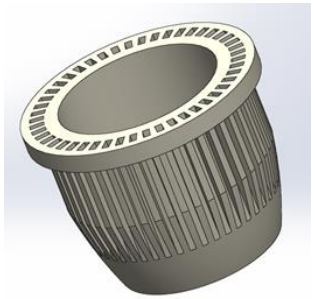
Application Example - Effective Heat Sink Designs with Thermally Conductive Plastics (TCP)

BN Powders

Pellets

Product



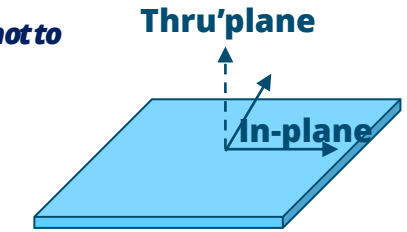


Properties of Unfilled Plastics vs. Thermally Conductive Plastics

Property	Neat Plastics	CoolFlow*-based Plastics
In-plane TC (W/mK)	0.2	up to 10
Through-plane TC (W/mK)	0.2	up to 2
Volume resistivity (Ω-cm)	10^{14}	10^{12} – 10^{14}
Dielectric strength (V/mil)	600	300 – 800
Tensile strength (MPa)	80	45 – 75
Impact strength (J/m)	53	25 – 35

Note: Typical properties are average data and are not to be used as or to develop specifications.

Plastic = PA6



*** CoolFlow is a trademark of Momentive Technologies Inc.**

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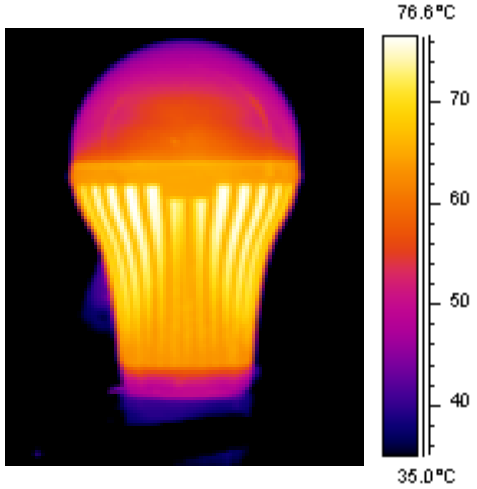
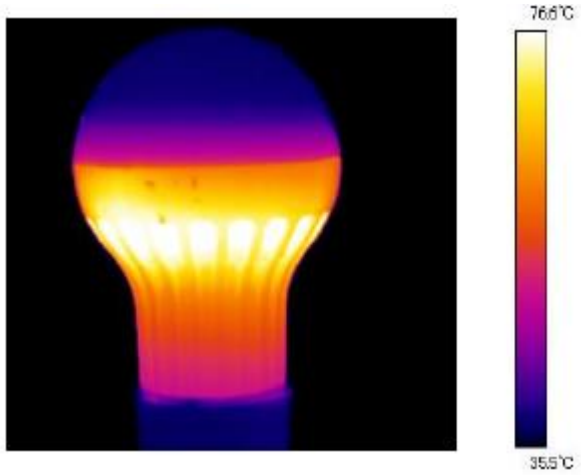
Light-weight LED cooling housing enabled by BN filled TCP

10 W LED bulb
(~ 60 W incandescent bulb)
Aluminum Housing



10 W LED bulb
(~ 60 W incandescent bulb)
BN-filled Plastic Housing



Note: Test data. Actual results may vary

In both cases, the temperature of the hottest spot on the heat sink was in the same range

Caveats:
- ***Bulbs employ different heat sink designs***
- ***LED chip efficiency in each bulb unknown***
- ***Internal assembly differences may affect LED die junction temperature***

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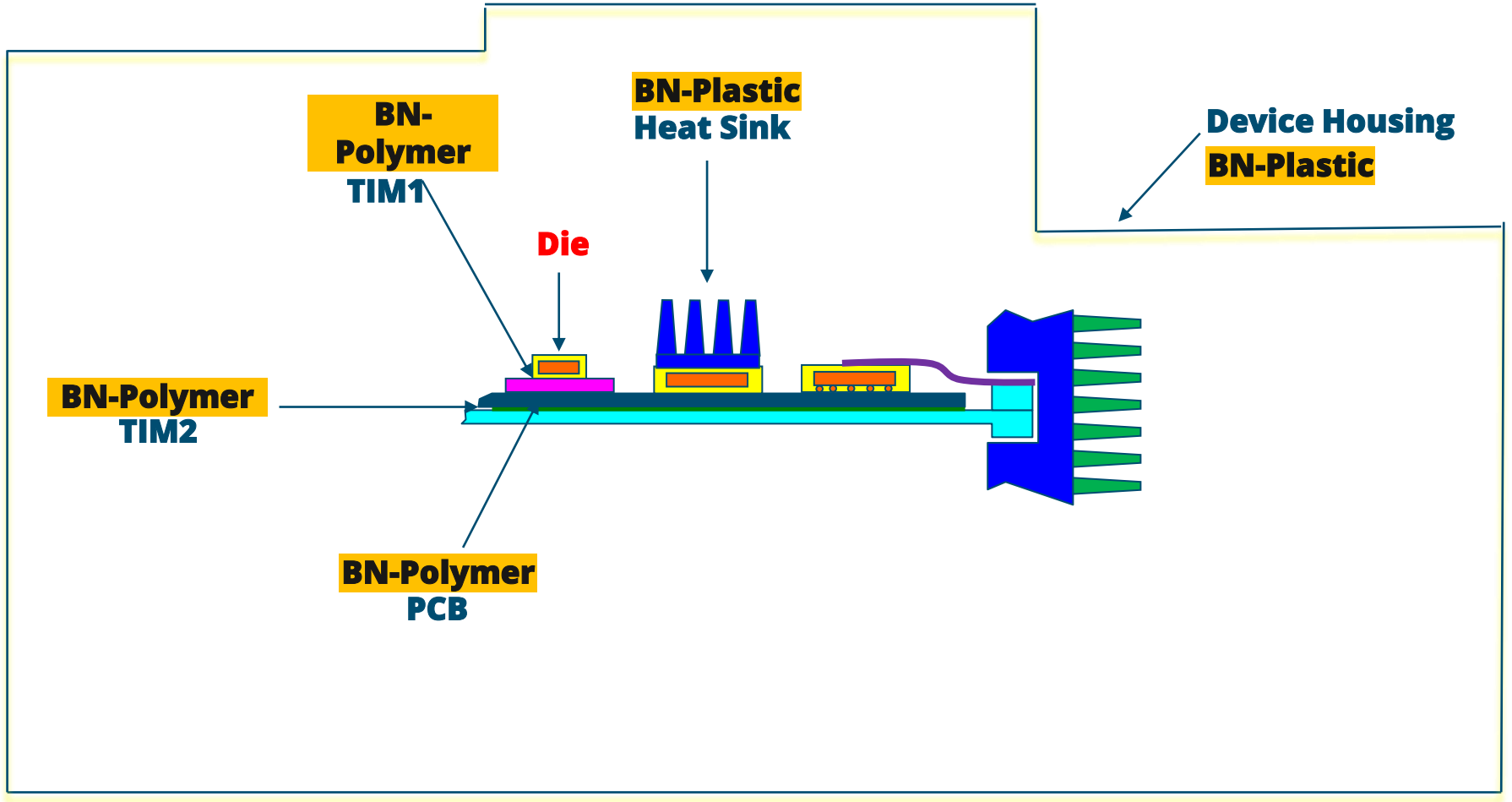
BN Thermal Management Solution in Electronic Devices

Thermal management materials using BN solution



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Summary

- **Unique features:** high thermal conductivity, high electrical resistivity, low dielectric constant, low hardness, light weight.
- **Broad range of choices:** large BN powder portfolio with various properties and morphologies tailored for a variety of applications.
- **Enable better performance in smaller package:** Increased power, increased reliability, extended life, reduced size and weight, and reduced cost for customer
- **Renowned solution provider:** strong technology and application development teams.

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