NANODIMENSION

Electrifying Additive Manufacturing®

AME Materials Technical Datasheet

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1. Introduction

The DragonFly® IV system can print Conductive Ink (CI) and Dielectric Ink 1092 (DI) simultaneously to enable the production of Additively Manufactured Electronics (AME) and Hi-PED (high performance electronic devices). Printing with both inks concurrently while maintaining a high print resolution, the DragonFly® platform has limitless design flexibility in multiple applications and industries. These include communications, RF, medical devices, drones, aerospace, automotive, satellites, in-circuit transformers, antennas, coils, capacitors, inserted components and more.

2. Dielectric Ink 1092 - Dielectric UV Curable Acrylate Ink

Winner of the IDTechEx Technical Development Materials 2018 Award, the Nano Dimension dielectric ink, Nano Part # CSA-000014, NND-MAT-DI-003, is designed to complement conductive AgCite® nano-silver ink and provide essential electrical insulation, including when printing at or below a thickness of one hundred microns. The ink contains excellent, uniform dielectric properties that have so far been tested up to a frequency of 65GHz, thus enabling a variety of applications in the electronic market from DC to RF.

Table 1 shows the dielectric constant (Dk) and the tangential loss (Df) as a function of frequency. These measurements were taken using a SPEAG DAK-TL3.5-P contact probe beam on the surface at 22±3°C.

Frequency	200MHz	1GHz	2.5GHz	5GHz	7.5GHz	10GHz	30GHz	40GHz	50GHz	65GHz
Dielectric Constant (Dk)	2.96	2.89	2.85	2.83	2.81	2.80	2.83	2.82	2.82	2.81
Tangential loss (Df)	0.034	0.026	0.018	0.018	0.021	0.021	0.016	0.016	0.016	0.014

***Table 1** - Dielectric properties: Dk and Df as functions of operational frequencies*

Property	DI 1092	Unit	Condition	Test Method*
Dielectric breakdown (Thickness 1.6mm)	41.7	kV		IPC-TM-650, 2.5.6
Volume resistivity	7.07E+09	MΩ•cm	After humidity conditioning	IPC-TM-650, 2.5.17.1
Surface resistivity	6.67E+09	MΩ	After humidity conditioning	IPC-TM-650, 2.5.17.1
Arc resistance	134	Sec		IPC-TM-650, 2.5.1
Dimensional Stability	99.9	%	After thermal stress (4h, 105°C)	IPC-TM-650, 2.4.39
Moisture absorption	1.30	%		IPC-TM-650 2.6.2.1
Tensile strength	63	MPa	23 °C	ASTM D638
	58	MPa	23 °C	ISO 527
Elongation at break	10	%	23 °C	ASTM D638
	7	%	23 °C	ISO 527
Elastic Modulus	2.4	GPa	23 °C	ISO 527
Flexural strength	106	N/mm^2	23 °C	IPC TM-650 2.4.4
Flexural Modulus	2.2	GPa	23 °C	IPC TM-650 2.4.4
Impact Resistance (notched)	13	J/m	23 °C	ASTM D256
	16	J/m	23 °C	ISO 180
CTE (TMA) (thickness ≥ 0.5 mm)	136	ppm/°C	35°C-230°C, no pretreatment	IPC-TM-650 2.4.24

Property	DI 1092	Unit	Condition	Test Method*
	103	ppm/°C	35°C-120°C, pretreatment: 105 °C, 2 h	
	133	ppm/°C	35°C-230°C, pretreatment: 105 °C, 2 h	
Decomposition temp. (Td 2%) (TGA)	309	°C		IPC-TM-650 2.4.24.6
Decomposition temp. (Td 5%) (TGA)	351	°C		
Tg (DMA, 10 Hz, tan delta)	145	°C		IPC-TM-650 2.4.24.4
Thermal conductivity	0.181	W/mK	25 °C	ASTM E1530-19
	0.200	W/mK	120 °C	
	0.220	W/mK	200 °C	
Density	1.18	g/cm3	23 °C	ASTM D792
Roughness (Ra)	<2.5 Top	µm		IPC-TM-650, Method 2.2.22
	<0.25 Bottom	µm		
%TML (outgassing)	0.49	%		ASTM 595-15
%CVCM (outgassing)	<0.01	%		ASTM 595-15
%WVR (outgassing)	0.24	%		ASTM 595-15
Note: Test methods are used as a reference for the testing methodology only. The IPC specifications for PCBs do not apply to AME technology.				

Table 2 - Physical, thermal and electrical Properties

Safety & Handling

Read and practice the safety guidelines described in: Dielectric Ink 1092 MSDS.

3. AgCite® 90072 Silver Nanoparticle Conductive Ink

Winner of the IDTechEx Technical Development Materials 2018 Award, AgCite™ conductive ink (Nanoparticle Silver Ink, Nano Part # CSA-000013, NND-MAT-CI-002) is based on pure silver particles that have controlled characteristics such as shape and particle distribution. This ensures that each batch of AgCite™ nano-silver ink is suitable for a wide range of additive manufacturing for electronic applications, while maintaining excellent conductivity and adhesion. Furthermore, unlike regular metal powders that require high sintering temperatures, AgCite™ nano-silver inks can achieve a sintering temperature low enough for compatibility with Nano Dimension's dielectric Ink.

Property	AgCite 90072	Test Method
Conductivity (silver nano particles) * (S/m) at 20 °C]	$2.21x10^7 \pm 0.95x10^7$	Printing & sintering conditions dependent
Max reflow solder temperature [°C] **	165	Using: Quick Chip TS391LT (138°C***)/ KOKI TB48-M742 (138°C***) Paste.
Max manual soldering temperature [°C] **	220	
Roughness Ra	Top surface <2µm, Bottom surface 0.25µm	IPC-TM-650, Method 2.2.22
Elementary analysis after sintering [%wt]	Ag: 96.1, C: 3.9	EDS (Energy Dispersive X-ray Spectroscopy) (Oxford) (Detection limit: 0.5%)
* Bulk silver conductivity = 6.30×107 σ (S/m) at 20°C ** Refer to Manual Soldering of DragonFly AME Devices application notes. *** Melting temperature per vendor's specification.		

Table 4 - Physical, thermal, and electrical Properties

Safety & Handling

Read and practice the safety guidelines described in AgCite® 90072 MSDS.

4. Reliability

IMPORTANT

The Hi-PEDs were submitted to reliability tests based on IPC-650 and passed successfully:

- **IST (Interconnect Stress Test) over 300 thermal cycles in the range of RT (Room Temperature) to 100°C.**
- **HATS (Highly Accelerated Thermal Shock) over 500 thermal cycles in the range of 0 to 70°C.**
- **Mechanical shock (TM 2.6.5) and Vibration (TM 2.6.9) (Hi-PED dimensions: 80 x 60 x 1.6 mm^3)**

5. Stability

Hi-PEDs can be stored in a zipped bag - conductivity is guaranteed for up to 6 months.

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