

# Nanotech Conductive Inks

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## Conductive Inks with Low-Temperature Curing

For applications using a wide range of coating techniques including inkjet, spray, spin, dip, screen, slot-die, blade, flexographic and gravure printing and more.

**NANOTECH ENERGY**

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nanotechenergy.com

Graphene, Silver  
Nanoparticles and  
Nanowires

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Fast Drying,  
Eco-Friendly and  
Chemically Stable

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Good for Printed,  
Flexible  
Electronics

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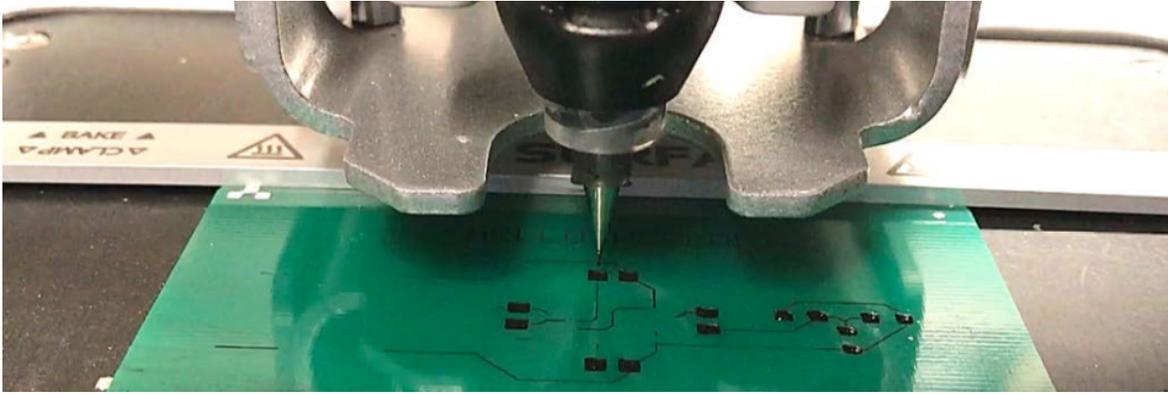
Water & Solvent  
Based Inks

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Large Quantities  
available

# Overview

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Similar to conventional printing, printed electronics applies ink onto paper, plastic or other substrates. Because electrical conductors are essential for printed electronic devices, significant efforts have been devoted to the development of functional conductive materials. Nanotech Energy has developed graphene and graphene-based materials with superb electronic structure and therefore can provide excellent properties including high chemical and thermal stability as well as outstanding electrical conductivity. Applications includes thin film transistors, transparent conducting electrodes, sensors, RFIDs, photovoltaics, printed circuits, etc. Our proprietary graphene inks can also provide very high specific surface area, which would be beneficial for printed batteries and supercapacitors. We can also tune the properties of our inks for a variety of coating / printing techniques.

**Inkjet Printing**

**Screen Printing**

**Gravure Printing**

**Flexographic Printing**

**Spray Coating**

**Printed Circuit Boards**

**RFID**

**Smart Fabrics**

**Conductive Coatings**

**Battery &  
Supercapacitors  
Electrodes**

**EMI Shielding**

**Printed Transistors,  
Memory and Sensors**

**Large Area Heaters**

# How Do We Compare?

INK	NANOTECH ENERGY									
	METAL FLAKES		CONDUCTIVE POLYMER		CNT		METAL NANOWIRES, NANOPARTICLES		GRAPHENE	
<b>Conductivity</b>	4	1	3	4	3	4	3			
<b>Processability</b>	2	3	3	4	4	4	4			
<b>Curing temperature</b>	1	4	3	3	4	4	4			
<b>Mechanical properties</b>	2	1	3	4	4	4	4			
<b>Cost</b>	1	2	1	2	4	4	4			

The market for flexible and printed electronics is rapidly growing as a low-cost alternative to silicon technology. Flexible displays, photovoltaics and circuitry have advanced the global market of this technology and conductive inks are evolving to meet these requirements. This table shows the state-of-the-art conductive inks offering unique properties suitable for particular applications. Conductive inks vary from metal flakes (silver and copper) and conductive polymers (such as PEDOT/PSS) to carbon materials (carbon nanotubes and carbon black). These materials are either expensive (such as silver flakes and carbon nanotubes), chemically unstable (copper) or do not have sufficient conductivity (conductive polymers) or mechanical flexibility (carbon black) needed for printed electronics. Nanotech Energy is developing a variety of conductive inks to address these issues and to satisfy the growing demands for printed electronics.

# Nanotech Conductive Ink Specifications - Long Term Plan

Nanotech Energy offers a variety of conductive inks for printed electronics. Please consider our selection of conductive silver, graphene, carbon nanocomposites, specifically designed to meet the performance demands for many applications.



	Nanoink1	Nanoink2	Nanoink3	Nanoink4	Nanoink5
Chemistry	Graphene-based	Graphene-based	Graphene-based	Silver nanoparticles	Silver nanoparticles
Solvent	Water and solvent	Solvent	Water	Water, ethanol, isopropyl alcohol	Water and hydrocarbon
Viscosity (cps)	2300-2400 typical 100-1000 also possible	10-12	10-12	≤ 4	Tunable (2-20)
Sheet resistance ( $\Omega/\square$ /mil)	≤ 32	8-40	8-40	≤ 0.0056	≤ 0.004
Conductivity (S/cm)	≥ 12.5	10-50	10-50	≤ 70,000	≤ 100,000
Particle size	2D sheets lateral size: Nominal ≤ 30 Qm; Typical: 10 Qm	2D sheets lateral size ≤ 3 Qm	2D sheets lateral size ≤ 3 Qm	Spherical particles Diameter: ≤ 0.1 Qm	Spherical particles Diameter: 5, 10, and 20 nm
Solid content	5.5 % (w/w), typical ≤ 20% (w/w) also possible	2 mg/mL	2 mg/mL	.5 - 2% (w/w) (5-20 mg/mL) based on customer request	30-60% (w/w)
Applications	Screen, slot-die, flexographic and gravure printing	Inkjet, Spray and Spin Coating	Inkjet, Spray and Spin Coating	Inkjet	Inkjet
Curing temperature	Room T	Room T	Room T	150°C	120°C

# Why Graphene Ink?



## WORLD'S FIRST

Nanotech Energy owns what can arguably be considered the world's first graphene patent filed in May of 2002. Nobel Prize winning researchers Sir Andre Geim and Konstantin Novoselov first work on graphene was published two years later. Since 2002, Nanotech Energy has staked its claims on 28 patents in graphene production, processing, applications and much more.

## HIGHEST SURFACE AREA OF ANY GRAPHENE IN THE MARKET

Graphene offers impressive combination of high strength, chemical stability and excellent conductivity. We are currently producing graphene via rapid and environmentally friendly methods, which represents a key to low-cost manufacturing of flexible and printed electronics, composites and novel energy solutions. We also offer two forms of graphene whose electronic conductivity has been optimized to meet the needs of our customers. With over 2000 m<sup>2</sup>/g, Nanotech Energy offers graphene with the world's largest specific surface area of any commercial graphene. As a result, this graphene shows potential to transform the industry of printed electronics enabling devices such as solar cells, flexible displays, thin film transistors, photodetectors, supercapacitors, batteries, sensors, etc.

	HG	PG
Material	Graphene, Process H	Graphene, Process P
Surface area* (m <sup>2</sup> /g)	2519	2057
Conductivity (S/m)	1047	3615
Sheet size	Adjustable (0.1 to 10 μm)	Adjustable (0.1 to 10 μm)



# Applications

Nanoink and Argentumink can be processed into coatings with extremely high electrical conductivity for applications by inkjet printing, screen printing as well as a variety of other processes. The products are compatible with many substrate surfaces including plastics, glass, and ceramics. Nanotech offers superior conductive inks and coatings to address a wide variety of applications including:



Solar Cells



Flexible Electronics



Printed Circuits



RFID for  
Product Tracking

## APPLICATIONS

<b>Solar cells</b>	<b>Battery &amp; supercapacitor electrodes</b>
<b>Flexible displays</b>	<b>Heat dissipation</b>
<b>Smart fabrics</b>	<b>Coatings for tantalum capacitors</b>
<b>EMI shielding</b>	<b>Water separations and purification</b>
<b>Sensors</b>	<b>Corrosion protection</b>
<b>RFID antennas</b>	<b>Large area heaters</b>
<b>Membrane switches</b>	<b>Touch screens</b>