Recommended Properties for IDS NanoJet Inks

IDS has successfully printed a variety of materials with the NanoJet Aerosol Printer. Printed inks include conductive nanoparticle and precursor formulations, dielectric, adhesive, and organic semiconductor formulations, water-based formulations for biological applications, and other colloidal and dissolved solid formulations. To be successful, inks must be compatible with the ultrasonic aerosolization process the printer uses. Typical inks that are formulated for inkjet printing can normally be printed with the NanoJet. Based on IDS' experience, the following properties are important when designing an ink for the NanoJet printer. This document is meant to provide guidelines and a starting point for ink formulation.

Caution: to prevent damage, review your printer's chemical compatibility requirements as listed in the user manual before using a new ink or solvent.

Ink Attribute	Recommendation	Notes
Solvent	Polar or non-polar. Examples include DMAc, PGMEA, Toluene, Hexane, Xylenes and water. Avoid alcohols. Inks formulated from isopropanol, ethanol, and methanol are generally unstable.	Glycol-based inks are typically difficult to atomize and have generally low mass output rates. Improved aerosolization and increased mass output can be obtained by diluting glycol-based inks with a suitable solvent.
Co-solvent	Examples include PGME, Ethylene Glycol, Propylene Glycol, D-Limonene, Terpineol. 1:10 ratio by volume to main solvent. 50 – 100 cP	Addition of a co-solvent improves print quality by preventing excessive drying during aerosol transport from atomizer to substrate. Co-solvents help maintain wet deposition.
Viscosity	Less than 10 cP	As viscosity increases, mass output typically decreases.
Surface tension	Less than 30 dyne cm	Higher surface tension liquids are typically difficult to atomize, and result in poor substrate wetting.
Foaming	Foaming is detrimental to aerosol generation	Foaming causes unstable aerosol generation. Surfactants can be used to reduce foaming and stabilize aerosol output. Check for foaming by shaking the ink by hand.
Substrate Compatibility	Application dependent	Typical substrates of interest are Polyimide (Kapton), Glass, Silicon, Polyethylene Terephthalate (PET), Silicone, and Polycarbonate
Metal nanoparticle size (if applicable)	Less than 50 nm	Particle mass increases rapidly as the particle diameter increases. Large mass particles (with diameter > 75 to 100 nm) are difficult to atomize. In addition, smaller particles (diameters < 50 nm) typically demonstrate lower resistivity after sintering.

Print Performance	Recommendation	Notes
Adhesion	ASTM 3359 cross hatch adhesion test	Cross hatching is not performed if the substrate is soft. For those substrates, only the tape pull is performed.
Stability during Printing	Less than 10% coefficient of variance of resistance, volumetric output, and line width over 4 hours. 8-hours is desired.	For nanoparticle inks, the ink must remain in suspension during printing. The ink should be minimally affected by the energy of the ultrasonic atomizer or by temperature increases up to 50°C.
Minimum sintering / curing temperature	No specific recommendation. Requirements are application dependent	Typically, lower sintering temperatures and shorter sintering time-at-temperature are desirable attributes for Flexible Hybrid Electronics inks.
Resistivity after sintering/curing	No specific recommendation. Requirements are application dependent	There is industry interest in materials which demonstrate 2-3 X bulk resistivity. This requirement may not be critical for specific applications.

References

Guided ink and process design for aerosol jet printing based on annular drying effects, Ethan B Secor 2018 Flex. Print. Electron. 3 035007

Impact of storage conditions and storage time on silver nanoparticles' physicochemical properties and implications for their biological effects, RSC Adv., 2015, 5, 84172