Nano inks with novel functionalities

GenesInk highlights its new transparent conductive inks and hole transport layer inks for transparent electrodes and photovoltaics applications

GenesInk is an SME specialised in metallic and semi-metallic nanomaterials and nanoinks manufacturing for consumer electronics applications. The company was created in 2010 in France and is nowadays employing more than 20 talented persons (80% in R&D&I) and has sales offices and distributors in Taiwan, Japan, and USA. GenesInk has more than 12 patent families with more than 60 patents worldwide. The manufacturer's actual range of products comprises more than 40 different nanoinks available on the market.

Focus on innovation

Nowadays, GenesInk enables consumer electronics that previously were not thought to be possible:

- Flexible and foldable active packaging, smartphones, and screens.
- Connected wearables such as eyeglasses and biosensors.
- Transparent and flexible layers for photovoltaics applications.

The French company is facilitating end to end processes: not only do they develop nanomaterials and formulate inks; they also help customers to set up printing processes and implement new printed components into their end-devices. By doing this, they are not selling the inks, but rather new functionalities. Genesink designs nano inks with novel functionalities at their core from particle synthesis to the printed end product. In doing so, electronics are freed up to enable a new generation of consumer electronics, claims the company.

Solutions to the consumer electronics market

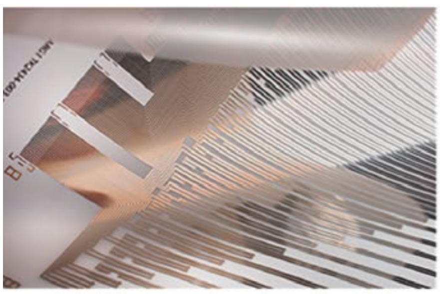
GenesInk is offering nanoparticle-based inks to the market. With nanoparticles, low temperature processed flexible substrates such as polymers, cellulose, and papers, can be considered for electronic applications. These nano inks can be produced at industrial scale and are designed with combined mechanical and optical functionalities at the core – flexibility, stretchability, thinness, high resolution, and transparency. The (conductive) nano inks are designed with ultra-high power efficiency. According to the manufacturer, they are up to five times more conductive than market leaders with seven to eight times less materials used. GenesInk also highlights that its nano inks are designed and produced in a way that is respectful to humans and the environment.

Know-how

Three types of nanomaterials are offered to the market by GenesInk:

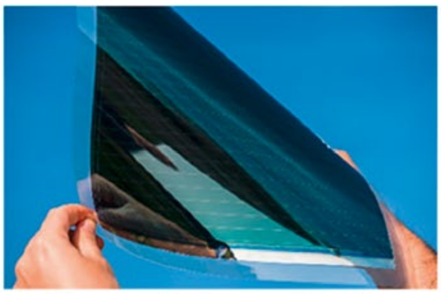
- The SmartInk silver-based nano inks are designed for printing highly conductive and flexible electronics. SmartInk products are cured at low temperatures, enabling the use of flexible substrates, and resulting in faster drying and lower sheet resistances than comparable silver products. SmartInk products are specifically designed for conductive interconnects, busbars, and antenna functionalities.
- The Tranductive nano ink based on Ag nanowires (Ag NW) is one of the most promising alternatives to ITO (Indium Tin Oxide). With the emergence of new technologies such as flexible PV and displays, ITO films are outperformed as they are difficult to process, brittle and delaminate frequently. Tranductive nanoinks are designed to be applicated by standard coating processes and compatible with plastic substrates thanks to their low drying temperature.
- Based on metal oxides (zinc oxide (ZnO), aluminium doped zinc oxide (AZO), and tungsten oxide (WO_3)), HeliosInk products are semi-conductive inks and can be used as charge transport layer in photovoltaic cells (solar energy), and lighting (OLED) applications.

In the further course of this article, we will focus on Tranductive and HeliosInk. Ag NW-based inks for transparent conductive electrodes (TCE) and WO_3 nanoparticle (NPs) based inks for hole transport layer (HTL) applications, respectively.



Highly conductive flexible circuits -SmartInk range

Smart screen applications – Tranductive range



Photovoltaics applications (solar cells) – HeliosInk range

GenesInk's nanoinks ranges and their targeted applications.

Ag NW based nano inks for TCE applications

Transparent conductive electrodes (TCE) for optoelectronic devices lack of flexibility due to the use of non-flexible, expensive, and short supply materials such as ITO., However, the current market is eager to achieve better flexibility to create more flexible devices. GenesInk provides nano inks based on Ag NW that are typically used to produce flexible, transparent, and conductive films. Their solution based on Ag NW (Figure 1) exhibits low resistivity keeping the viscosity adapted for various deposition processes. GenesInk aims to enhance (i) Ag NW adhesion to cellulosic and polymer substrates (5B ASTM D3359), (ii) up to 90% the transmittance, and (iii) reach sheet resistances lower than 10Ω/sq resistivity. Their performances are up to 10% higher than ITO standard, and fit applications for conductive papers and conductive electrodes. So far, GenesInk has reached 5B adhesion with Ag NW inks without altering the conductivity (7 – 30 Ohm/sq) and the transparency (80 – 89%) by adding specific additives to basic formulations.

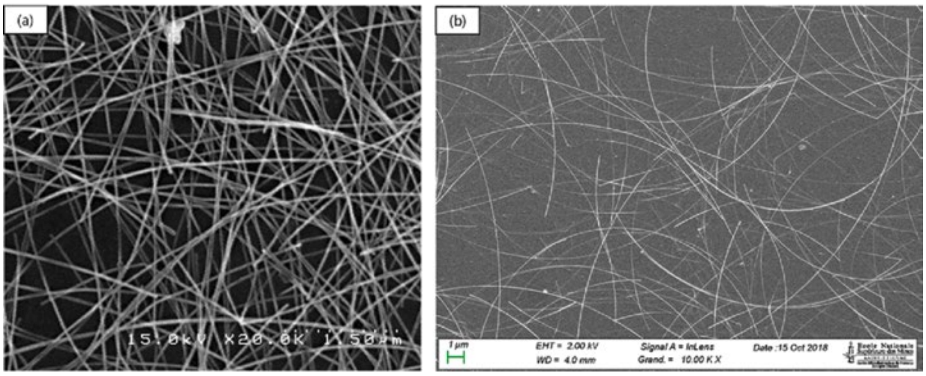


Figure 1: Scanning Electron Microscopy Ag NW based inks by GenesInk: (a) Tranductive N based on Ag NWs; (b) Tranductive E based on Ag NW and ZnO

WO_3 based nano inks – HTL

Compared to the state-of-the-art, GenesInk also offers also WO_3 based nano inks (Figure 2) for HTL applications with the following advantages:

- WO_3 is a safe metal oxide (MOx) causing no harm to operators and environment compared to NiO, MoO_3 and V_2O_5, which are classified or suspected as carcinogenic, mutagenic, or toxic to reproduction.
- WO_3 nano ink is solution processable, which means it can be deposited by eco-friendly printing techniques while MOx are commonly deposited by heavy methods such as chemical vapour deposition (CVD), anodising, etc.
- WO_3 nano ink is based on nanoparticles smaller than 10nm. Nanoparticles have higher specific surface areas than microparticles and thus a higher efficiency than larger particles.

OPV devices developed with GenesInk's WO_3 nano ink as HTL were performed, tested and compared to organic PEDOT:PSS in standard OPV and evaporated molybdenum oxide (MoOx) in inverted OPV (Table 1). On one hand, GenesInk's nano inks exhibit equivalent properties compared to evaporated metal oxides and solution processable PEDOT:PSS. On the other hand, WO_3 nano inks are deposited by additive techniques compared to MoOx and exhibit better UV stability and chemical compatibility compared to PEDOT:PSS. Therefore, devices using GenesInk's nano inks exhibit a stability of 1000 hours when exposed to 85°C/85% RH (Relative Humidity) during aging tests while PEDOT:PSS containing devices degrade almost completely after 336 hours of exposure to high temperature and humidity (aging tests). Indeed, organic HTL-based devices are unstable and degrade in harsh atmospheric conditions .

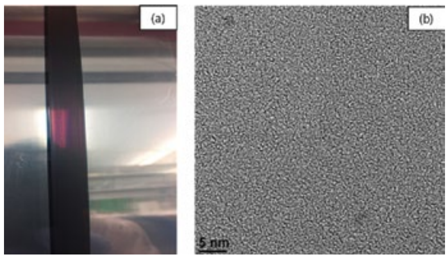


Figure 2: (a) Homogeneous WO3 nanoinks printed on active layer (b) Transmission Electron Microscopy of WO3 films

In the framework of the MADRAS project, GenesInk will enable new functionalities to their materials and address new markets such as geo-tracking tags and fingerprint sensors.

Image sources: GenesInk and partners

Acknowledgment: CNR - ISOF; AUTH – LTFN; MADRAS H2020 project partners

HTL material	OPV structure	TCE	Active layer	PCE%	Jsc (mA/cm²)	Voc (V)
HeliosInk SW41011 GenesInk	Inverted	ITO	HBG1:PC61BM	5.6	11.3	0.80
MoOx (evaporated)	Inverted	ITO	HBG1:PC61BM	6.0	13.8	0.76
HeliosInk SW41014 GenesInk	Standard	ITO	Bulk heterojunction	3.7	7.9	0.72
PEDOT:PSS	Standard	ITO	Bulk heterojunction	3.5	7.4	0.74

Table 1: GenesInk's WO_3 nano inks tested in OPV devices and compared to evaporated MoOx and printed PEDOT:PSS