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Influence of different type protective layer on silver metallic nanoparticles for Ink-Jet printing technique

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Protection layer around of nAg particles is builded on them during each type of reaction of producing nano Ag size stuctures.

Role of protection layer is to be the barrier against nAg particles agglomeration process and making stable colloids without sedimentation phenomena.





Amepox R&D Works With Nanosilver Powder

For preparing nAg with particles less 10 nm, Amepox is working with thermal decomposition of silver type chemicals.



Raw material



Nanosilver after wasching and

drying process

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Reactor chamber



Nanosilver



nAg suspension - INK



Ink Jet System – General Info

Nozzle diameter	10-100 μm
Droplet volume	10 – 500 picoliters
Drop speed	1,5-2,5 m/s
Drop rate*	2000/s
Max. Throughput	0.5 µl/s
Viscosity range	0,5 – 20 mPas (unheated) 20-10000 mPas (heated)

* depending on the liquid and capilar diameter







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Slow Motion Shoot Nanol nk by Ink Jet Dispenser





Role of Protection Layer on nAg – Filler For EC Inks





Application of EC Inks

Electronic applications requirements are, that structures made with nAg powder fillers has to be highly electrical conductive with very stable conductive value after "curing" process – similar like bulk silver material.



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Application of EC Inks





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Protective coatings examples

Charged (*electrostatic*):





Carboxylate



Polymer (*steric - chemical*):





R: acrylic, polystyrene, PEO, PPO, etc



Metalic NanoSilver as a Filler for Ink Preparation





Measurement of particle size "Malvern" (Courtesy Polish Academy of Sciences)

SEM picture nAg particlesi (Courtesy Polish Academy of Sciences)

The dynamics of removing carboxylate coating at 150 °C and 230 °C as a function of time of Ag1



Purity analysis of Aq1: content of carboxylate coating - 1,1 %, removal of carboxylate coating at 230 °C & 1 hour - 0,8 %, removal of carboxylate coating at 150 °C & 1 hour - 0,6 %



Metalic NanoSilver as a Filler for Ink Preparation



Nanosilver with amine protective coating – Ag2 size ab.50 nm (*electrostatic*)



Measurement of particle size "Malvern" (Courtesy Polish Academy of Sciences)

SEM picture nAg particlesi (Courtesy Polish Academy of Sciences)

The dynamics of removing amine coating at 150 °C and 230 °C as a function of time of Ag2



Purity analysis of Ag2: content of amine coating – 0,2 %, removal of amine coating at 230 °C & 1 hour – 0,19 %, removal of amine coating at 150 °C & 1 hour – 0,19 %



Metalic NanoSilver as a Filler for Ink Preparation



Nanosilver with polymer protective coating – Ag3 size 50–70 nm (*chemical*)



Measurement of particle size "Malvern" (Courtesy Polish Academy of Sciences)

SEM picture nAg particlesi (Courtesy Polish Academy of Sciences)

The dynamics of removing polymer coating at 150 °C and 230 °C as a function of time of Ag3



Purity analysis of Ag3: content of polymer coating – 0,8 %, removal of polymer coating at 230 °C & 1 hour – 0,4 %, removal of polymer coating at 150 °C & 1 hour – 0,25 %



Summary:

- Example of three nanosilvers with different kinds of protective layers were prsesnted.
- The particles diameter was in range 50 100 nm and each kind of studied nanosilver with carboxylate, amine and polymer protective materials were uniformly distribution.
- The maximum protection material volume for low temperature nanoink should be in the range of about 1.1 1.5% bw.
- Removing the protection layer is the key for obtaining good and stable conductive properties.
- Amepox R&D works is connected with developing new types of nano silver with different sizes and protective layers and their influence on electrically conductive ink properties.



Actual and future research

The low temperature ink base properties:

- Low sintering temperature 120 150 °C
- Low viscosity 2 15 mPas
- Sizes of silver 30 60 nm
- Content of silver up to 20 %
- Very good printability on flexible and and low temp. substartes.





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Thank you for your attention.



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