Hybrid gold nanoparticles with conductive polymer ligands

Indra Backes[1], Beate Reiser[1], Lola Gonzalez-Garcia[1], David Doblas Jiménez[1], and Tobias Kraus[1]

[1] *INM – Leibniz Institute for New Materials, Saarbrücken, Germany*

Current printed electronics are often made using inks that contain noble metal nanoparticle dispersions to exploit the good electrical properties of metals [1, 2]. Sufficient colloidal stability in dispersion is provided by bulky organic molecules that ensure steric stabilization at the expense of the electrical conductivity of the dried material. After the printing process, post-treatments are usually required in order to remove the insulating ligands and enhance conductivity. The required temperatures often exclude flexible substrates like polymer foils [3]. Here, we describe sintering-free inks that overcome this challenge.

We demonstrated that gold nanorods stabilized by water-soluble, semiconducting polymers combine high colloidal stability and electrical conductivity upon drying (Fig. 1). Inks prepared using these hybrid nanostructures exhibit high shelf-life in water and alcohols, but are not stable in unpolar organic solvents [4]. The printing of electronic systems such as multilayer devices requires to tailor ink properties, in particular viscosity and wetting behavior. Aqueous dispersions cannot fulfil the requirements for some devices, and we are developing sintering-free inks that are based on unpolar organic solvents.

We will discuss two strategies to stabilize hybrid nanoparticles in organic media. In the first approach, spherical gold nanoparticles capped by oleylamine are functionalized by a conjugated polymer ligand in a direct ligand exchange reaction. In the second, we use a two-step reaction to stabilize hybrid gold nanorods in unpolar organic solvents. First, we functionalize the gold nanorods to enable phase transfer from the aqueous to the organic phase. The intermediate gold nanorods are then modified by semiconducting polymers in a final step.

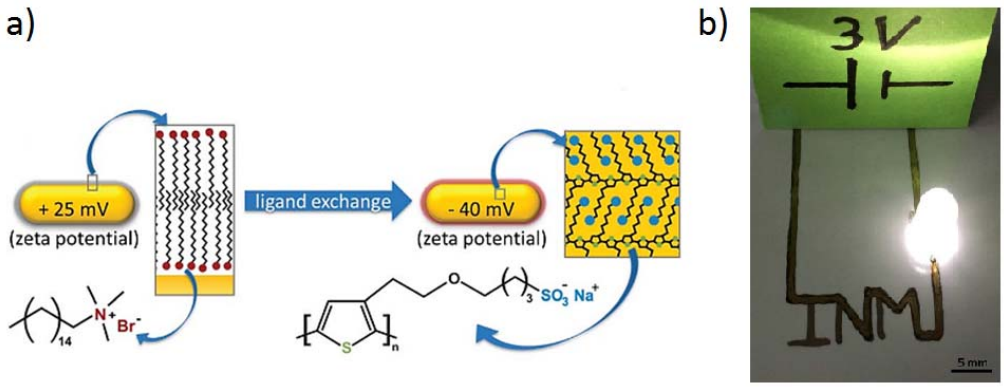

Figure 1. a) Schematic surface modification of gold nanorods with semiconducting, water-soluble polythiophene ligands. b) Circuits produced by the aqueous sintering free hybrid inks.

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