Biomedical and Energy Applications of Bare Nanoparticle Building Blocks made by Lasers in Liquids

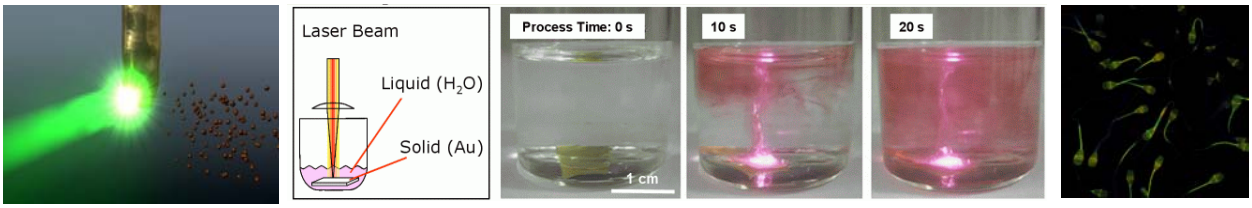
Prof. habil. Dr.-Ing. Stephan Barcikowski,

Technical Chemistry I; Center for NanoIntegration Duisburg-Essen CENIDE; NanoEnergieTechnikZentrum NETZ, Univ. Duisburg-Essen. http://www.uni-due.de/barcikowski

Size matters. After decades of intensive nanoresearch, nanoparticles are widely implemented as functional elements on surfaces, into volumes and as nanohybrids, with biomedical application prospects as drug releasing **nanoparticle-polymer-composites or nanoparticle-bioconjugates** and **energy** application by **heterogeneous catalysts**.

However, nowadays only a limited variety of materials that may be integrated into advanced functional products are available: Nanoparticles synthesized by conventional gas phase processes are often agglomerated to micropowders that are hardly re-dispersible into functional matrices, and chemical methods often lead to impurities of the nanoparticle colloids caused by additives and precursor reaction products. These residuals may desactivate the nanoparticle´s surface and require cleaning steps which compromise the colzloidal quality or yield. As alternative synthesis route, **laser ablation of solids in liquids** has proven its capability to generate nanoparticles with utmost purity, being highly affine for conjugation, both with hard and soft matter:

Related to chemical energy conversion application, deposition of naked nanoparticles on inorganic and carbon supports creates heterogeneous catalysts with **100% cumulative yield**, with mass loading up to 60% adjustable without changing catalyst particle size.



Scale-up of the method is shown at the example of polymer matrix embedding, fabricating **kilogram scale** of **polymer membrane** nanocomposites essential in artificial lung implants.

Laser-generated gold and monophasic gold-silver-alloy nanoparticles particularly profit from purity, which allows their application in biomedicine without cross effects. Hence this reference material is used to model unintended implant debris toxicity using a very sensitive biofunctional system: **mammalian reproduction biology**.

Also **conjugation to biomoleclules** starts from scratch (the bare surface), allowing preecise control of ligand load. Intendetly, **charge balancing** of gold nanoprobes conjugated by oppositely charged ligands (DNA/LNA with amphhiphilic cell penetrating peptides) allowed to study nanoparticle assembly at distinct membrane sites and shutteling **non-endocytotically into sperms**, through acrosome reaction.

General Ref´s:

- Barcikowski, S. ; Compagnini, G.: Advanced Nanoparticle Generation and Excitation by Lasers in Liquids. Phys. Chem. Chem. Phys. 15 (2013), 9, 3022–3026
- Rehbock, C. ; Jakobi, J. ; Gamrad, L. ; Van der Meer, S. ; Tiedemann, D. ; Taylor, U. ; Kues, W. ; Rath, D. ; Barcikowski, S.: Current state of laser synthesis of metal and alloy nanoparticles as ligand-free reference materials for nano-toxicological assays. Beilstein Journal of Nanotechn. 5 (2014), 1523-1541
- Merk, V. ; Rehbock, C. ; Becker, F. ; Hagemann, U. ; Nienhaus, H. ; Barcikowski, S.: In Situ Non-DLVO Stabilization of Surfactant-Free, Plasmonic Gold Nanoparticles: Effect of Hofmeister's Anions. Langmuir 30 (2014),15,4213-4222.
- YouTube Channel (of published videos shown during the talk): http://youtube.com/nanofunction

BioMed Ref´s:

- Gamrad, L.; Rehbock, C.; Krawinkel, J.; Tumursukh, B.; Heisterkamp, A.; Barcikowski, S.; Charge Balancing of Model Gold-Nanoparticle-Peptide Conjugates Controlled by the Peptide's Net Charge and the Ligand to Nanoparticle Ratio. Journal of Physical Chemistry C (2014), 118 (19), 10302-10313.
- Barchanski, A.; Taylor, U.; Sajti, C. L.; Gamrad, L.; Kues, W. A.; Rath, D. Barcikowski, S.: Bioconjugated gold nanoparticles penetrate into spermatozoa depending on plasma membrane status; Journal of biomedical nanotechnology, vol. 11 (2015) ; doi:10.1166/jbn.2015.2094

Catalyst Ref:

- Marzun, G. ; Streich, C. ; Jendrzej, S. ; Barcikowski, S. ; Wagener, P.: Adsorption of Colloidal Platinum Nanoparticles to Supports: Charge Transfer and Effects of Electrostatic and Steric Interactions. Langmuir 30 (2014), 40, 11928-11939