Multifunctional nanoparticles for biosensing and medical imaging

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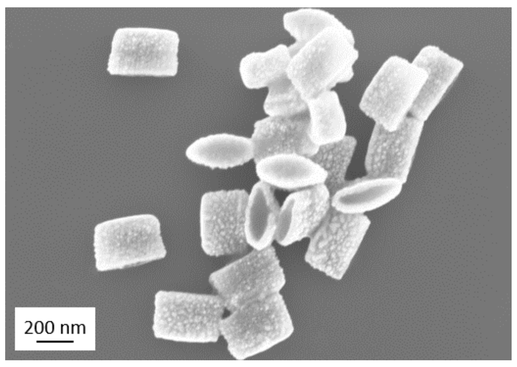
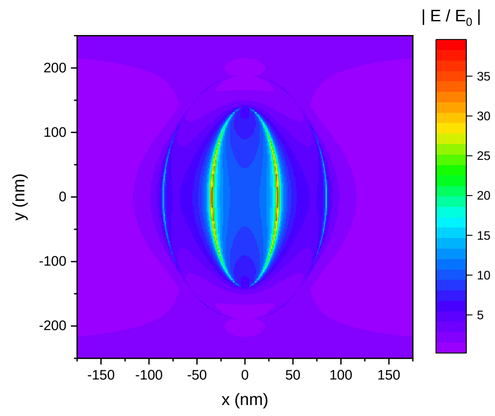
Fabricated nanoparticles



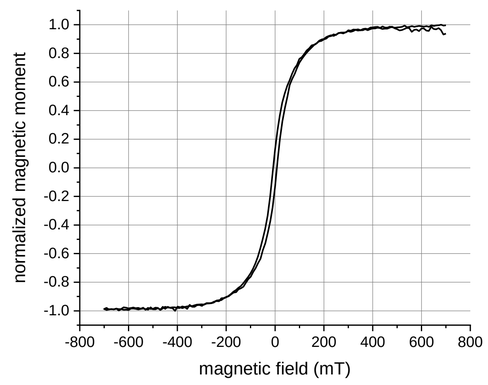
Nanopockets with nano-cavities

Optical characterization



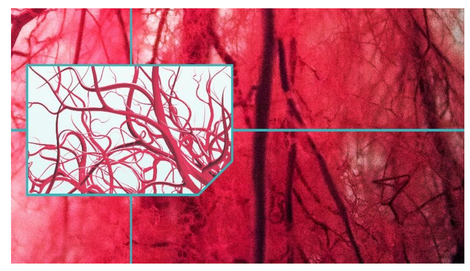
Electric field enhancement |E/E0|

Magnetic characterization



Magnetic hysteresis loop

Biosensing and Imaging



Detection of protein biomarkers & Biomedical imaging

Introduction

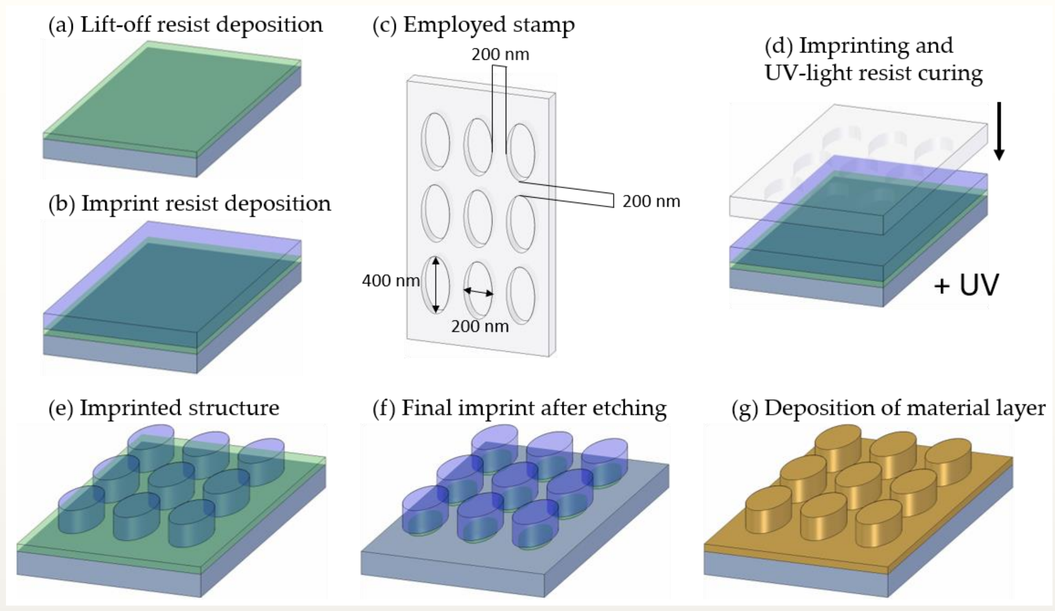
Nanostructured surfaces and nanoparticles are already widely employed in many different fields of research, and there is an ever-growing demand for novel types of nanoparticles. This is especially valid for multifunctional nanoparticles with physical properties that match the needs of a specific application. Additionally, there is an increasing need for improved medical imaging and fast and sensitive biosensing technologies.

We present the fabrication of three types of nanomaterials. Specifically, we present surfaces comprising a highly uniform array of elliptical pillars, nanoparticles with the shape of elliptical nanoplatelets as well as nanoparticles with the shape of nanopockets, possessing nano-cavities.[1,2] Optical and magnetic characterization reveals multifunctional properties of the fabricated nanomaterial. Furthermore, we report on the application of nanoparticles as probes for biosensing and as contrast agent for medical imaging.

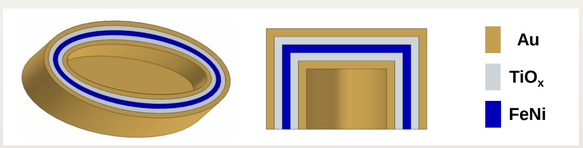
Nanoparticle fabrication

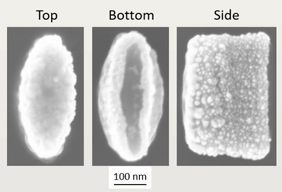
The structures are fabricated by nanoimprint lithography, physical and wet-chemical etching and sputter deposition of thin films of various materials to achieve a novel multifunctional nanomaterial with defined optical and magnetic properties.

Scheme of fabrication process:



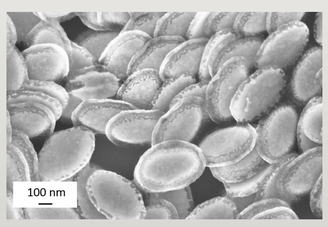
Nanopockets:





Nanoplatelets:

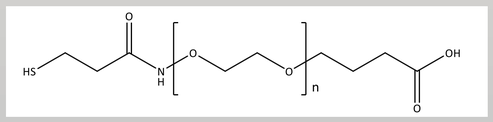
Layer system		
Material	**Thickness (nm)**	**Functionality**
Au	30	Plasmon layer
TiO_x	10	Decoupling layer
NiFe	10	Magnetic layer
TiO_x	10	Decoupling layer
Au	30	Plasmon layer
AZO	20	Release layer



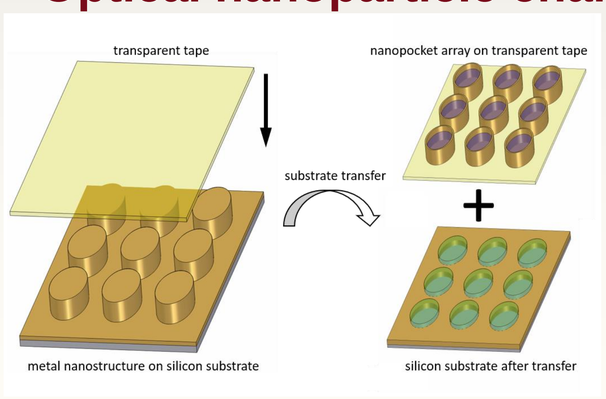
Surface modification and dispersion stabilization

Use of an additional linker molecule to stabilize aqueous nanoparticle dispersions and to allow for carbodiimide crosslinker chemistry for antibody binding (EDC/S-NHS).[1]

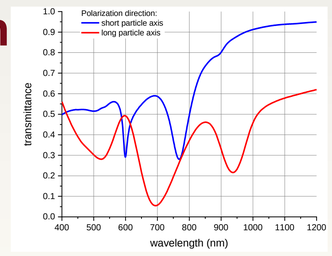
thiol-PEG-carboxy



Optical nanoparticle characterization



Optical simulation



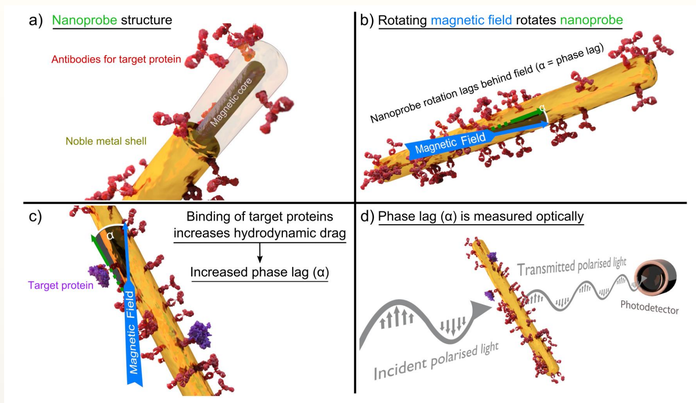
Minima peak positions

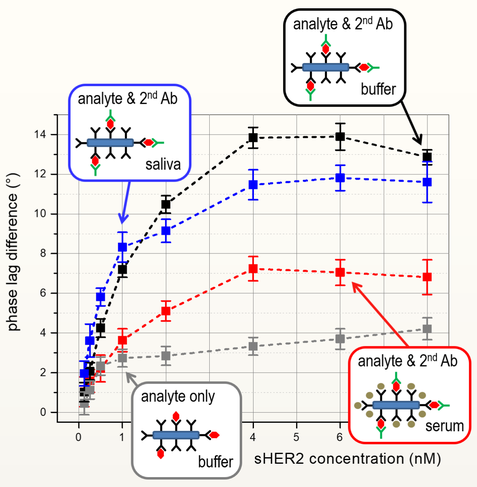
Parallel polarization		Perpendicular polarization	
experiment	**simulation**	**experiment**	**simulation**
531 nm	525 nm	652 nm	599 nm
771 nm [1]	695 nm	727 nm	768 nm
974 nm	938 nm	907 nm	885 nm [1]

Optical properties can be tailored to specific demands by predictive modeling steps

Biosensing and Imaging

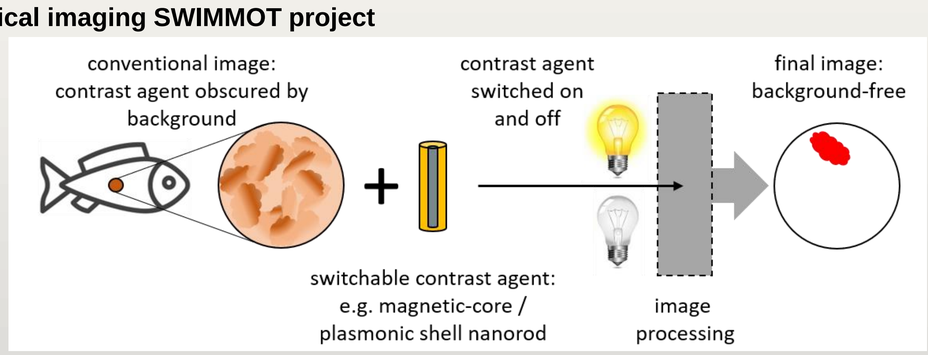
Biosensing principle: Rotational dynamics of magnetic nanoparticle probes change upon analyte binding



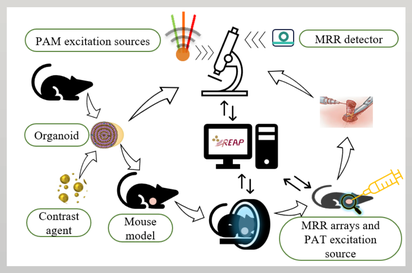


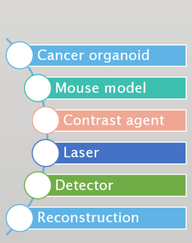
The breast cancer biomarker sHER2 (soluble domain of the transmembrane protein HER2) can be detected in complex sample solutions of saliva and serum if secondary antibodies (2nd Ab) are added to the assay. The extrapolated limit of detection is in the lower nM regime (e.g. 1.7 nM for saliva).[3,4,5]

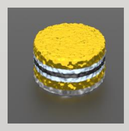
Biomedical imaging SWIMMOT project



Biomedical imaging REAP project







Nanoplatelet particles serve as base for the contrast agents

The optical properties are tailor-made for the imaging technology

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http://www.swimmot.researchproject.at

https://www.projectreap.eu/

http://lampion.iiss.at/

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