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Overview

RESEARCH PROGRAMME
Colloidal Nanoplasmonics for biomedical applications
The research activity of the BioNanoPlasmonics Lab is focused on the synthesis and formation mechanisms of (plasmonic) metal nanoparticles with controlled composition, size and morphology; the creation of colloidal composites, including functionalized carbon nanostructures and Janus particles; nanostructured thin films and nanoparticle ordered arrays in one, two and three dimensions; the optical characterization of nanoparticles and their assemblies; and the use of metal nanoparticles as biosensors.

SCIENTIFIC OUTPUT
The scientific activity of BioNanoPlasmonics Laboratory in 2016 can be summarized as follows: 37 publications in high impact scientific journals, 4 PhD thesis defended and 4 ongoing, >30 invited lectures and seminars and 3 awards.

GROUP MEMBERS
During 2016 the group led by Prof. Luis M. Liz-Marzán has been composed by 25 researchers (3 research associates, 11 postdoctoral researchers, 8 Ph.D. students and 3 research technicians) and a project manager.
GROUP MEMBERS

2016 Group Members

Luis M. Liz-Marzán  
Ikerbasque Professor  
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Marek Grzelczak  
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# GROUP MEMBERS

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## GROUP MEMBERS

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<tr>
<th></th>
<th>CIC biomaGUNE Platform Manager</th>
<th>Ada Herrero-Ruiz Research Technician</th>
<th>Anna Llanes-Pallàs CIC biomaGUNE Project Manager</th>
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<tr>
<td>Judith Langer</td>
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<td>Ada Herrero</td>
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<td>Anna Llanes</td>
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## VISITING RESEARCHERS

- **Piotr Piotrowski** Visiting Student from University of Warsaw, Poland (01/11/2016 - 31/04/2017)
- **Hector Navarro** Visiting Student from Fundación Instituto de Investigación Marqués de Valdecilla, Santander, Spain (12/12/2016 – 16/12/2016)
- **Daisuke Nagao** Visiting Professor from Tohoku University, Japan (19/09/2016 - 23/09/2016)
- **Johan Hofkens** Visiting Professor from KU Leuven, Belgium (30/08/2016 - 23/09/2016)
- **Javier Garcia de Abajo** Visiting Professor from ICFO, Barcelona, Spain (08/08/2016 - 20/08/2016)
- **Matthias Thiele** (University of Jena)
- **Jonas Van Rie** Visiting Student from University of Leuven, Belgium (03/10/2016 – 31/10/2016)
- **Karolina Kinastowska** Visiting Student from Wroclaw University of Technology, Poland (17/10/2016 – 21/12/2016)
- **Piotr Szustakiewicz** Visiting Student from University of Warsaw, Poland (13/07/2016 – 29/09/2016)
- **Cristine Payne** Visiting Professor from Georgia Institute of Technology, USA (23/05/2016 - 11/07/2016)
- **Angela Candreva** Visiting Student from University of Calabria (21/05/2016 - 31/10/2016)
- **Leonora Velleman** Visiting Researcher from Imperial College London, UK (15/04/2016 - 17/05/2016)
- **Forough Ghasemi** Visiting Student from Sharif University of Technology, Iran (06/01/2016 – 05/04/2016)
Scientific Output

AWARDS

Highly Cited Researcher
Luis Liz-Marzán was included in 2016 lists of *Highly Cited Researchers List (Clarivate Analytics)*, in two fields: Chemistry and Materials Science.

Outstanding PhD Award to Leonardo Scarabelli
The PhD thesis presented by Leonardo Scarabelli, "Rational Synthesis and Self-Assembly of Anisotropic Plasmonic Nanoparticles", has been selected by the University of Vigo for the Outstanding thesis award of 2016. Many congratulations on a very well deserved recognition for his excellent work!

Outstanding Abstract Award to Malou Henriksen-Lacey
Malou Henriksen-Lacey has received an award for Outstanding Abstract at the International Conference on Nanomedicine and Nanobiotechnology, *ICONAN 2016*. Malou's abstract was entitled "Thermosensitive nanogels with multiple anti-tumour associated effects" and was selected among all the contributions to the conference. Congratulations to Malou and also to Malte Strozyk and Susana Carregal-Romero, the main co-authors of the work.

FELLOWSHIPS

Marie Skłodowska-Curie Individual Fellowship
Dr. Jatish Kumar was awarded with a Marie Skłodowska-Curie Individual Fellowship to conduct the project CINMAB “Chiral Plasmons in Protein-Nanoparticle Hybrid Materials for Application as Biosensors” at the BNP Lab.

Feodor Lynen Research Fellowship
Dr. Christoph Hanske was awarded with a Feodor Lynen Research Fellowship from the Alexander von Humboldt Foundation to conduct his postdoctoral studies at the BNP Lab.

Polish Postdoctoral Fellowship
Dr. Wiktor Lewandowski was awarded with a Mobilnosc Plus fellowship to conduct his postdoctoral studies at the BNP Lab.

EDITORIAL ACTIVITY

Luis Liz-Marzán

Editor:
- Co-Editor-in-Chief, *ACS Omega*, ACS (2016 -)
- Board of Reviewing Editors, *Science*, AAAS (2013 -)
Editorial Boards:

- Editorial Advisory Board, Accounts of Chemical Research, ACS (2016 -)
- Advisory Board, Faraday Discussions, RSC (2015 -)
- International Advisory Board, ChemNanoMat, Wiley-VCH (2014 -)
- Editorial Board, Chemistry – A European Journal, Wiley (2014 -)
- Editorial Advisory Board, ACS Nano, ACS (2013 -)
- Executive Editorial Board, Particle & Particle Systems Characterization, Wiley (2012-)
- International Advisory Board, Advanced Optical Materials, Wiley (2012 -)
- Editorial Advisory Board, Chemistry of Materials, ACS (2012 -)
- Executive Editorial Board, Particle & Particle Systems Characterization, Wiley (2012-)
- Editorial Advisory Board, ChemistryOpen, publicada por Wiley (2011 -)
- Editorial Board, Theranostics, Ivyspring (2011 -)
- Advisory Board, Nano Today, Elsevier (2006 –)
- Sensing and Actuation Editor, Nanotechnology, IOP Science (2015 - 2016)
- Editorial Advisory Board, Hybrid Materials, Versita (2012 -2016)

Guest Editor:

Luis Liz-Marzán


Marek Grzelczak


PhD THESES

Ana Belén Serrano Montes
Gold Nanostars: Synthesis, Stabilization and Applications as Surface Enhanced Raman Scattering Tags
Universidade de Vigo/CIC biomaGUNE, Febrero 2016
Director: Luis Liz-Marzán

Leonardo Scarabelli (Outstanding PhD Award)
Rational Synthesis and Self-Assembly of Anisotropic Plasmonic Nanoparticles
Universidade de Vigo/CIC biomaGUNE, Febrero 2016
Director: Luis Liz-Marzán

Andrea La Porta
Engineering The Morphology and Organization of Gold Nanostructures for SERS Detection
Universidade de Vigo/CIC biomaGUNE, Febrero 2016
Director: Luis Liz-Marzán

Marc Coronado Puchau
Biosensing Using Metal Nanoparticles
Universidade de Vigo/CIC biomaGUNE, Febrero 2016
Director: Luis Liz-Marzán; Co-Director: Jorge Pérez Juste
SCIENTIFIC OUTPUT

INVITED LECTURES AT CONFERENCES, COURSES AND WORKSHOPS
Luis Liz-Marzán

1. *Nanotecnología Aplicada a Imagen y Manipulación Celular*
   Jornada Técnica Modelos Animales en Terapia Celular, ISCIII Madrid, (15 Jan 2016)

2. *Nanocrystal Growth and Characterization (Plenary, 3h)*
   Workshop on Nanoparticle Synthesis, Kish Island, (7–10 Mar 2016)

3. *Self-Assembly of Colloidal Plasmonic Nanostructures (Plenary)*
   International Conference on Nanostructures, Kish Island (Iran), (7–10 Mar 2016)

4. *Nanoplasmonic Sensing of Bacterial Growth (Plenary)*
   EUROPTRODE XIII, Graz, (20–23 Mar 2016)

5. *La Química y la Física de los Metales en la Nanoescala*
   Reunión Anual de la Real Academia de Ciencias, RAC Madrid, (13 Apr 2016)

6. *Detección Nanoplasmónica: Conceptos y Materiales*
   Master en Nanotecnología Medioambiental, Universidad de Zaragoza, (9 May 2016)

7. *Hybrid Materials for Biosensing*
   PhD School on Materials Science and Nanotechnology, University of Milano-Bicocca (20 May 2016)

8. *Interfacing Plasmonic Nanomaterials with Living Cells*
   Interfacing Interfacial Science Symposium, Berlin (26 May 2016)

9. *Molecular Thinking for Nanoplasmonic Design*
   Jornadas Doctorales, Universidad Autónoma de Barcelona, (1-3 Jun 2016)

10. *Hybrid Nanomaterials for Biosensing*
    SCHeMA Summer School, Plentzia (14-16 Jun 2016)

11. *Monitoring Bacterial Growth through Plasmonics (Plenary)*
    5th International Iberian Biophysics Congress, Lisboa (15-17 Jun 2016)

12. *Graphene and Carbon Nanotubes as Supports for Plasmonic Nanomaterials*
    Symposium "A journey through carbon nanostructures: from fullerene to graphene", Toledo (27 Jun 2016)

13. *Organic Ligands on Inorganic Nanoparticles*

14. *Hierarchical Oriented Assembly of Gold Nanorods*
    META 2016, Torremolinos (25-28 Jul 2016)

15. *Hierarchical Assembly of Gold Nanoparticles for SERS Biosensing*
    252nd ACS National Meeting, Philadelphia (21-25 Ago 2016)

16. *Assembly and Patterning of Anisotropic Nanoparticles (Plenary)*
    Journées de la Matière Condensée, Bordeaux (22-26 Ago 2016)

17. *Making and Measuring in Nanoplasmonic Sensing (Plenary)*
    SALSA School of Analytical Sciences Adlershof, Berlin (5-9 Sep 2016)

18. *Synthesis and Chemical Modifications in Metal Nanocrystals (Topic Plenary)*
    EuChemS 2016, Sevilla (13-16 Sep 2016)
19. Hybrid Substrates for SERS Biodetection (Keynote)
   Italian Meeting on Raman Spectroscopies and Non Linear Optical Effects, Padova (14-16 Sep 2016)

20. Chemical Growth and Transformation of Metallic Nanostructures. Inorganic Chemistry at the Nanoscale (Plenary)
   XLIV Congresso Nazionale di Chimica Inorganica Della Societa Chimica Italiana, Padova, (14-17 Sep 2016)

21. Directed Self-Assembly of Nanoparticles (Plenary)
   AutoOrg, Brasil, (2-4 Nov 2016)

INVITED SEMINARS
Luis Liz-Marzán
1. Composite Nanomaterials for Biosensing
   Universitat Jaume I, Castellón (Ene 2016)
2. Composite Plasmonic Nanomaterials for Biosensing and Bioimaging
   Cavendish Laboratory, University of Cambridge (Ene 2016)
3. Engineering Nanoplasmonic Colloids into Sensing Devices
   CIQUS, Universidad de Santiago de Compostela (Feb 2016)
4. Nanomateriales Plasmónicos para Detección y Diagnóstico
   Universidad de Castilla La Mancha, Toledo (May 2016)
5. Engineering Nanoplasmonic Colloids into Sensing Devices
   Penn State University (Ago 2016)
6. Chemical Growth of Metal Nanoparticles, Why and How?
   Instituto de Química Orgánica General (CSIC, Madrid), (Oct 2016)
7. Composite Plasmonic Nanomaterials: Prospects in Biosensing and Catalysis
   Debye Institute, Utrecht University (Oct 2016)
   Universidade de São Paulo (Oct 2016)
   Universidade de Campinas (Nov 2016)
10. The Art and Science of Growing and Assembling Metal Nanocrystals
    Instituto de Ciencia de Materiales de Aragón, CSIC (Nov 2016)

PRESENTATIONS AT CONFERENCES BY GROUP MEMBERS
Marek Grzelczak

The Use of Plasmonic Nanoparticles in Photochemical Reactions (Plenary talk)
XLV Winter Meeting on Statistical Physics, Taxco, Mexico (11-13 Jan 2016)

Can plasmonic particles catalyse formation of other plasmonic particles? (Oral)
Workshop On Supramolecular Systems Chemistry, Barcelona, Spain (29 Feb - 02 Mar 2016)
Conjugated Polymers A Molecular Gates for Light-Controlled Release of Gold Nanoparticles (Oral)
POLYMAT SPOTLIGHT, San Sebastián, Spain, (21-24 Jul 2016)

Self-assembly of Nanoparticles Through Hydrophobic Interactions (Keynote)
30th European Crystallography Meeting - ECM-30, Basel, Switzerland (28 Aug – 01 Sep 2016)

Self-Assembled Composite Colloids and Their Application to SERS Detection (Keynote)
Interfaces Against Pollution Conference - IAP16, Lleida, Spain (4-7 Sep 2016)

Javier Reguera
Patchy nanoparticles at the air-liquid interface: contact angles and adsorption energies measured by neutron reflectivity (Oral)
NanoSpain, Logroño, Spain, (15-18 Apr 2016)

Synthesis of Janus plasmonic-superparamagnetic, star-sphere nanoparticles, and their application in SERS detection (Oral)
Faraday Discussions: Nanoparticles with morphological and functional anisotropy, Glasgow, UK (4-6 June 2016)

Characterization of patchy nanoparticles at the air-water interface and development of novel Janus magneto-plasmonic nanoparticles (Oral)
SoftComp Annual Meeting, Ancona, Italy (6-9 Jun 2016)

Patchy Nanoparticles. Properties and Characterization (Invited)
Global Biotechnology Congress, Boston (21-25 Aug 2016)

Synthesis of Janus plasmonic-superparamagnetic, star-sphere nanoparticles, assembly and SERS applications (Poster)
International Conference on Self-Assembly in Confined Spaces, San Sebastián (25-27 Oct 2016)

Isabel García-Martín
Stability and targeting properties of glycan-decorated plasmonic Au nanoparticles: Toward a selective SERS-based nanosensor (Oral)

Enhancing Immune Response with Gold Nanoparticle-based Delivery Systems (Poster)
International Conference on Self-Assembly in Confined Spaces, San Sebastián (25-27 Oct 2016)

Dorleta Jimenez de Aberasturi
Multiplexed SERS Cell Differentiation using Encoded-Gold Nanostars (Poster)
EUROPT(RO)DE XIII - Conference on Optical Chemical Sensors and Biosensors, Graz, Austria (20-23 March, 2016)

Novel SERS Encoded-Gold Nanostars as Multiple Cell Differentiators (Poster)
Nanax 7, Marburg, Germany (4-8 April 2016)

SERS Encoded Particles with Antibody Labeling for advanced Cell Tracking (Poster)
International Conference on Self-Assembly in Confined Spaces, San Sebastián (25-27 Oct 2016)
Malou Henriksen-Lacey
Thermosensitive nanogels with multiple anti-tumour associated effects (Oral)
International Conference on Nanomedicine and Nanobiotechnology – ICONAN, France, (28-30 Sep 2016)

Susana Carregal-Romero
Stimuli responsive membranes for the controlled release of colorimetric signals (Poster)
EUROPT(R)ODE XIII - Conference on Optical Chemical Sensors and Biosensors, Graz, Austria (20-23 March, 2016)

Thermoresponsive materials for nanoparticle and drug delivery (Poster)
Nanax 7, Marburg, Germany (4-8 April 2016)
Gold Loaded Thermoresponsive Nanogels with Multiple-Associated Anti-Tumour Effects (Poster)
International Conference on Self-Assembly in Confined Spaces, San Sebastián (25-27 Oct 2016)

Marta Quintanilla
Upconversion Quantum Yield in Lanthanide-Doped Nanoparticles: Going Deeper into Size, Shape and Host Material Dependencies (Oral)

Combining Lanthanide-Doped and Gold Nanoparticles to Modify Luminescence Intensity (Oral)
XXV International Materials Research Congress, Cancún, Mexico, (14-19 Aug 2016)

Eric H. Hill
Plasmonic Substrates for SERS Detection of Quorum-sensing (Poster)
EUROPT(R)ODE XIII - Conference on Optical Chemical Sensors and Biosensors, Graz, Austria (20-23 March, 2016)

Shape-templated Metal Nanoparticles on Layered Silicate Clay (Oral)
Nanax 7, Marburg, Germany (4-8 April 2016)

Monitoring Surface Topography Effects on Biofilm Growth by Surface-Enhanced Raman Scattering (Oral)
International Conference on Self-Assembly in Confined Spaces, San Sebastián (25-27 Oct 2016)

Christoph Hanske
Fabrication of anisotropic nanoparticle assemblies for metamaterials and SERS sensors (Poster)
Faraday Discussions: Nanoparticles with morphological and functional anisotropy, Glasgow, UK (4-6 June 2016)

Triblock Terpolymer Templated Plasmonic Clusters: Rational Design of Biosensing Probes (Poster)
Network Meeting of the Alexander von Humboldt Foundation - University of Freiburg, Germany (05-07 Oct 2016)

Assembly of Plasmonic Nanoparticles by Confinement in Mesostructured Templates (Poster)
International Conference on Self-Assembly in Confined Spaces, San Sebastián (25-27 Oct 2016)
**SCIENTIFIC OUTPUT**

**Alexander Johnson**  
Cell-Detachment from Plamonically Active Polyethylene Terephthalate (PET) Substrates by Application of Near-Infrared Light (Poster)  

**Wiktor Lewandowski**  
Dynamic self-assembly of silver nanoparticles for switchable SERS technology (Poster)  

**María Sanromán**  
Can Colloidal Biosensors Discriminate Single Nucleotide Polymorphism? (Oral)  
*III Reunión de Jóvenes Investigadores en Coloides e Interfases* - RSEQ-GECI, Spain, (13-14 Oct 2016)  
Sensitivity Limit of NP Biosensors in the Discrimination of Single Nucleotide Polymorphism (Poster)  

**Guillermo González-Rubio**  
Femtosecond Laser-Controlled Polymerization of Gold Nanorods (Poster)  
*Faraday Discussions: Nanoparticles with morphological and functional anisotropy*, Glasgow, UK (4-6 June 2016)  
Nucleation of Amyloid Oligomers of the RepA-WH1 Prionoid by Gold Nanorods (Oral)  
*III Reunión de Jóvenes Investigadores en Coloides e Interfases* - RSEQ-GECI, Spain, (13-14 Oct 2016)  
Femtosecond Laser-Controlled Tip-to-Tip Assembly and Welding of Gold Nanorods (Poster)  
Nucleation of Amyloid Oligomers of the RepA-WH1 Prionoid by Gold Nanorods (Oral)  

**Malte Strozyk**  
Gold loaded microgels as SERS devices for biological applications (Poster)  
*EUROPT(R)ODE XIII - Conference on Optical Chemical Sensors and Biosensors*, Graz, Austria (20-23 March, 2016)  
SERS Encoded Particles with Antibody Labeling for advanced Cell Tracking (Poster)  

**Ana Sánchez-Iglesias**  
Hydrophobic gold nanoparticles inside mesoporous hollow shell (Poster)  

**Judith Langer**  
Highly Stable SERS Nanotags for Long-Term Cell Imaging and Identification: Fabrication, Characterization & Application (Oral)  
*SERS Round Table* in Poltersdorf, Germany (11-13 Oct 2016)
SCIENTIFIC OUTPUT

Cell Imaging Using SERS-encoded Nanoassemblies with Multimodal Potential (Poster)
International Conference on Self-Assembly in Confined Spaces, San Sebastián (25-27 Oct 2016)

CONFERENCE AND WORKSHOP ORGANIZATION

Faraday Discussions on Nanoparticles with Morphological and Functional Anisotropy, Glasgow, UK (4 – 6 Jul 2016)


Scientific committee of the 2nd International Symposium on Nanoparticles/Nanomaterials and Applications, Caparica, Portugal (18 – 21 Jan 2016)

International advisory board of the NanoTech Poland, Poznan, Poland (22 – 25 Jun 2016)


RESEARCH PUBLICATIONS

   Quantitative 3D Analysis of Huge Nanoparticle Assemblies
   Nanoscale 2016, 8, 292-299. DOI: 10.1039/C5NR06962A

   Rabi Splitting in Photoluminescence Spectra of Hybrid System of Gold Nanorods and J-Aggregates

   Plasmonic Surfaces for Cell Growth and Near-Infrared Light Triggered Retrieval
   DOI: 10.1002/anie.201509025

   Inulin Coated Plasmonic Gold Nanoparticles as a Potential Tool for Cancer Therapy

   Electron Tomography Imaging of Janus Gold Nanoparticles Obtained via Spontaneous Binary Polymer Shell Segregation
Hierarchical Organization and Molecular Diffusion in Gold Nanorod/Silica Supercrystal Nanocomposites

Blocked Enzymatic Etching of Gold Nanorods: Application to Colorimetric Detection of Acetylcholinesterase Activity and its Inhibitors
ACS Appl. Mater. Interfaces 2016, 8, 11139-11146. DOI: 10.1021/acsami.6b01834

Hydrophilic Pt Nanoflowers: Synthesis, Crystallographic Analysis and Catalytic Performance
CrystEngComm 2016, 18, 3422-3427. DOI: 10.1039/c6ce00039h

Cancer cell internalisation of gold nanostars impacts their photothermal efficiency in vitro and in vivo: towards a plasmonic thermal fingerprint in tumoral environment

Exploring the Optical Non-Linearities of Plasmon-Exciton Hybrid Resonances in Coupled Colloidal Nanostructures
J. Phys. Chem. C 2016, 120, 12226-12233. DOI: 10.1021/acs.jpcc.6b04658

Chiral and Achiral Nanodumbbell Dimers: The Effect of Geometry on Their Plasmonic Properties
ACS Nano 2016, 10, 6180-6188. DOI: 10.1021/acsnano.6b02194

Blue Shifted Plasmon-Induced Resonance Energy Transfer from Single Gold Nanorods to Merocyanine Molecules
J. Phys. Chem. C 2016, 120, 14820-14827. DOI: 10.1021/acs.jpcc.6b04205

Quantitative Elemental Composition of Complex Hetero-Nanostructures by EDX Tomography

Plasmonic Substrates Comprising Gold Nanostars Efficiently Regenerate Cofactor Molecules

Layered Silicate Clays as Templates for Anisotropic Gold Nanoparticle Growth
Chem. Mater. 2016, 28, 5131-5139. DOI: 10.1021/acs.chemmater.6b02186

Encapsulation of Single Plasmonic Nanoparticles Within ZIF-8. Analysis of MOF Flexibility by SERS
Intracellular pH-Induced Tip-to-Tip Assembly of Gold Nanorods for Enhanced Plasmonic Photothermal Therapy
*ACS Omega* **2016**, *1*, 388-395. DOI: 10.1021/acsomega.6b00184

Silver Ions Direct Twin Plane Formation During the Growth of Single Crystal Gold Nanoparticle Seeds
*ACS Omega* **2016**, *1*, 177–181. DOI: 10.1021/acsomega.6b00066

Nucleating and Monitoring RepA-WH1 Amyloidogenesis with Gold Nanorods

Interfacial Activity of Gold Nanoparticles Coated by a Polymeric Shell and the Role of Spreading Agents
*ACS Omega* **2016**, *1*, 311–317. DOI: 10.1021/acsomega.6b00131

Application of Surface Enhanced Raman Scattering and Gated Materials to the Ultrasensitive Detection of Mycoplasma and Cocaine

Galvanic Replacement Coupled to Seeded Growth as a Route for Shape-Controlled Synthesis of Plasmonic Nanorattles
*J. Am. Chem. Soc.* **2016**, *138*, 11453-11456. DOI: 10.1021/jacs.6b06706

Gold Nanostar-coated Fluorescent Polystyrene Beads as Bifunctional Nanoprobes for in vitro Multimodal Imaging of Live Cells

Limiting Factors of Colloidal Biosensors in Discrimination of Single-Nucleotide Polymorphism
*ACS Sens.* **2016**, *1*, 1110-1116. DOI: 10.1021/acssensors.6b00393

Encoded-Gold Nanostars for Multiplexed SERS Cell Differentiation
*Chem. Mater.* **2016**, *28*, 6799-6810. DOI: 10.1021/acs.chemmater.6b03349
SCIENTIFIC OUTPUT

   Synthesis of Janus Plasmonic-Magnetic, Star-Sphere Nanoparticles and their Application to SERS Detection
   Faraday Discuss. 2016, 191, 47-59. DOI: 10.1039/c6fd00012f

   Fano interference in the optical absorption of a gold-silver nanodimer
   Nano Lett. 2016, 16, 6311-6316. DOI: 10.1021/acs.nanolett.6b02680

   Light-Directed Reversible Assembly of Plasmonic Nanoparticles Using Plasmon-Enhanced Thermophoresis
   ACS Nano 2016, 10, 9659-9668. DOI: 10.1021/acsnano.6b05486

   Detection and Imaging of Quorum Sensing in Pseudomonas Aeruginosa Biofilm Communities by Surface-Enhanced Resonance Raman Scattering
   Nature Mater. 2016, 15, 1203-1211. DOI: 10.1038/NMAT4720

   Morphology Control at the Nanoscale of Molecularly Imprinted Polymer (MIP)-Shell (Au@MIP) Sensors for Label-Free Antibiotic Analysis
   Chem. Mater. 2016, 28, 7947-7954. DOI: 10.1021/acs.chemmater.6b03613

   Tunable Nanoparticle and Cell Assembly Using Combined Self-Powered Microfluidics and Micro-contact Printing

REVIEWS

   Inorganic Nanoparticles for Biomedicine: Where Materials Scientists Meet Medical Research

   Formation, Reshaping and Assembly of Gold Nanoparticle Colloids Assisted by Pulse Lasers
   DOI: 10.1021/acs.accounts.6b00041

3. M. Simón, J.J. Giner-Casares
   Adherent Cell Culture in Biopharmaceutical Applications: The Cell-Detachment Challenge
   BioPharm International 2016, 29, 26-31
4. **J.J. Giner-Casares, J. Reguera**  
Directed self-assembly of inorganic nanoparticles at air/liquid interfaces  

5. **J. Kumar, T. George Thomas, L.M. Liz-Marzán**  
*Nanoscale Chirality in Metal and Semiconductor Nanoparticles*  

**EDITORIALS**

Chemistry, from Alpha to Omega, Open to All  
*ACS Omega* **2016**, 1, 1. **DOI**: 10.1021/acs.omega.6b00103
**ABSTRACTS OF SELECTED PUBLICATIONS**


**Plasmonic Surfaces for Cell Growth and Retrieval Triggered by Near-Infrared Light**  
J.J. Giner-Casares, M. Henriksen-Lacey, I. García, L.M. Liz-Marzán

Methods for efficient detachment of cells avoiding damage are required in tissue engineering and regenerative medicine. We introduce a bottom-up approach to build plasmonic substrates using micellar block copolymer nanolithography to generate a 2D array of Au seeds, followed by chemical growth leading to anisotropic nanoparticles. The resulting plasmonic substrates show a broad plasmon band covering a wide part of the visible and near-infrared (NIR) spectral ranges. Both human and murine cells were successfully grown on the substrates. A simple functionalization step of the plasmonic substrates with the cyclic arginylglycylaspartic acid (c-RGD) peptide allowed us to tune the morphology of integrin-rich human umbilical vein endothelial cells (HUVEC). Subsequent irradiation with a NIR laser led to highly efficient detachment of the cells with cell viability confirmed using the MTT assay. We thus propose the use of such plasmonic substrates for cell growth and controlled detachment using remote near-IR irradiation, as a general method for cell culture in biomedical applications.

**Nanoscale** 2016, **8**, 7914 – 7922. [DOI: 10.1039/C6NR00712K (Hot Article)]

**Hierarchical organization and molecular diffusion in gold nanorod/silica supercrystal nanocomposites**  

Hierarchical organization of gold nanorods was previously obtained on a substrate, allowing precise control over the morphology of the assemblies and macroscale spatial arrangement. Herein, a thorough description of these gold nanorod assemblies and their orientation within supercrystals is presented together with a sol–gel technique to protect the supercrystals with mesoporous silica films. The internal organization of the nanorods in the supercrystals was characterized by combining focused ion beam ablation and scanning electron microscopy. A mesoporous silica layer is grown both over the supercrystals and between the individual lamellae of gold nanorods inside the structure. This not only prevented the detachment of the supercrystal from the substrate in water, but also allowed small molecule analytes to infiltrate the structure. These nanocomposite substrates show superior Raman enhancement in comparison with gold supercrystals without silica owing to improved accessibility of the plasmonic hot spots to analytes. The patterned supercrystal arrays with enhanced optical and mechanical properties obtained in this work show potential for the practical implementation of nanostructured devices in spatially resolved ultradetection of biomarkers and other analytes.


**Janus gold nanoparticles obtained via spontaneous binary polymer shell segregation**  

Janus gold nanoparticles are of high interest because they allow directed self-assembly and display plasmonic properties. We succeeded in coating gold nanoparticles with two different polymers that form a Janus shell. The spontaneous segregation of two immiscible polymers at the surface of the nanoparticles was verified by NOESY NMR and most importantly by electron microscopy analysis in two and three dimensions. The Janus structure is additionally shown to affect the aggregation behavior of the nanoparticles.
Plasmonic Substrates Comprising Gold Nanostars efficiently regenerate cofactor molecules
The increasing attention toward the use of light in chemical processes is due to the technological and scientific interest in making use of inexpensive solar energy. Thus, there is a need for development of new bottom-up systems with efficient light harvesting capacity to facilitate relevant chemical reactions. In recent collaborative article, the researchers from Bionanoplasmic and Biosensing groups reported on photocatalytic regeneration of cofactor molecules using plasmonic particles of different shapes. Researchers have shown that macroscopic plasmonic substrates comprising gold nanostars exhibit better efficiencies than nanorods or cubes. The interplay of photochemical, photoelectrochemical measurements, supported by theoretical simulations, showed that the unique geometry of nanostars – radially distributed spikes – contributes to stronger light absorption by the plasmonic film containing that type of nanoparticles.

Reshaping, Fragmentation, and Assembly of Gold Nanoparticles Assisted by Pulse Lasers
The vast majority of the outstanding applications of metal nanoparticles (NPs) developed during the last two decades have arisen from their unique optical properties. Within this context, rational synthesis and assembly of gold NPs have been the main research focus, aiming at the design of nanoplasmonic devices with tailored optical functionalities. The progress made in this field is thus to be ascribed to the understanding of the origin of the interaction between light and such gold nanostructures, the dynamics of which have been thoroughly investigated with significant contributions from short and ultrashort pulse laser technologies. We focus this Account on the potential of pulse lasers to provide new fundamental insights into the electron dynamics involved in the interaction of light with the free conduction electrons of Au NPs, that is, localized surface plasmon resonances (LSPRs). The excitation of LSPRs with a femtosecond pulse laser is followed by thermalization of the Au NP electrons and the subsequent relaxation of the nanocrystal lattice and the surrounding environment, which generally results in surface melting. By contrast, nanosecond irradiation usually induces AuNP fragmentation and uncontrolled melting due to overlapping excitation and relaxation phenomena. These concepts have been exploited toward the preparation of highly monodisperse gold nanospheres via pulse laser irradiation of polyhedral nanocrystal colloids, or in the fabrication of nanostructures with “written-in” optical properties. The applicability of pulsed coherent light has been extended toward the direct synthesis and manipulation of Au NPs. Through ablation of a gold target in a liquid with pulse lasers, spherical Au NPs can be synthesized with no need of stabilizing ligands, which is a great advantage in terms of reducing toxicity, rendering these NPs particularly suitable for medical applications. In addition, femtosecond laser irradiation has been proven a unique tool for the controlled welding of plasmonic gold nanostructures by electromagnetic field enhancement at the hot spots of assembled Au NPs. The combination of such nanostructures with pulse lasers promises significant chemical and biochemical advances, including the structural determination of organic reaction intermediates, the investigation of phase transitions in inorganic nanomaterials at mild reaction conditions, or the efficient photothermal destruction of cancer cells avoiding damage of surrounding tissue.
**Detection and imaging of quorum sensing in *Pseudomonas aeruginosa* biofilm communities by surface-enhanced resonance Raman scattering**


Most bacteria in nature exist as biofilms, which support intercellular signalling processes such as quorum sensing (QS), a cell-to-cell communication mechanism that allows bacteria to monitor and respond to cell density and changes in the environment. As QS and biofilms are involved in the ability of bacteria to cause disease, there is a need for the development of methods for the non-invasive analysis of QS in natural bacterial populations. Here, by using surface-enhanced resonance Raman scattering spectroscopy, we report rationally designed nanostructured plasmonic substrates for the *in situ*, label-free detection of a QS signalling metabolite in growing *Pseudomonas aeruginosa* biofilms and microcolonies. The *in situ*, non-invasive plasmonic imaging of QS in biofilms provides a powerful analytical approach for studying intercellular communication on the basis of secreted molecules as signals.

**Cancer cell internalisation of gold nanostars impacts their photothermal efficiency in vitro and in vivo: towards a plasmonic thermal fingerprint in tumoral environment**


Gold nanoparticles are prime candidates for cancer thermotherapy. However, while the ultimate target for nanoparticle-mediated photothermal therapy is the cancer cell, heating performance has not previously been evaluated in the tumoral environment. A systematic investigation of gold nanostar heat-generating efficiency in situ is presented: not only in cancer cells in vitro but also after intratumoral injection in vivo. It is demonstrated that (i) in aqueous dispersion, heat generation is governed by particle size and exciting laser wavelength; (ii) in cancer cells in vitro, heat generation is still very efficient, but irrespective of both particle size and laser wavelength; and (iii) heat generation by nanostars injected into tumors in vivo evolves with time, as the nanostars are trafficked from the extracellular matrix into endosomes. The plasmonic heating response thus serves as a signature of nanoparticle internalization in cells, bringing the ultimate goal of nanoparticle-mediated photothermal therapy a step closer.

**Surface Enhanced Raman Scattering and Gated Materials for Sensing Applications: The Ultrasensitive Detection of *Mycoplasma* and Cocaine**


We report a novel combination of gated mesoporous silica nanoparticles (MSNs) and surface-enhanced Raman scattering (SERS) for sensing applications. As a proof-of-concept, we show the design of a system comprising MSNs loaded with crystal violet (CV), a molecule with high Raman cross section acting as SERS reporter, and capped with either a suitable DNA sequence for the detection of *Mycoplasma* genomic DNA or with an aptamer that selectively coordinates cocaine. In both cases the presence of the corresponding target analyte in solution (i.e., genomic DNA or cocaine) resulted in the release of CV. CV delivery was detected by SERS upon adsorption on gold nanotriangles (AuNTs), which display an efficient electromagnetic field enhancement and a high colloidal stability. By using this novel procedure a limit of detection of at least 30 copies DNA per μL was determined for the detection of *Mycoplasma* genomic DNA, whereas cocaine was detected at concentrations as low as 10 nm.
Galvanic Replacement Coupled to Seeded Growth as a Route for Shape-Controlled Synthesis of Plasmonic Nanorattles

Shape-controlled synthesis of metal nanoparticles (NPs) requires mechanistic understanding toward the development of modern nanoscience and nanotechnology. We demonstrate here an unconventional shape transformation of Au@Ag core–shell NPs (nanorods and nanocubes) into octahedral nanorattles via room-temperature galvanic replacement coupled with seeded growth. The corresponding morphological and chemical transformations were investigated in three dimensions, using state-of-the-art X-ray energy-dispersive spectroscopy (XEDS) tomography. The addition of a reducing agent (ascorbic acid) plays a key role in this unconventional mechanistic path, in which galvanic replacement is found to dominate initially when the shell is made of Ag, while seeded growth suppresses transmetalation when a composition of Au:Ag (~60:40) is reached in the shell, as revealed by quantitative XEDS tomography. This work not only opens new avenues toward the shape control of hollow NPs beyond the morphology of sacrificial templates, but also expands our understanding of chemical transformations in nanoscale galvanic replacement reactions. The XEDS electron tomography study presented here can be generally applied to investigate a wide range of nanoscale morphological and chemical transformations.

Tunable Nanoparticle and Cell Assembly Using Combined Self-Powered Microfluidics and Microcontact Printing

The combination of cell microenvironment control and real-time monitoring of cell signaling events can provide key biological information. Through precise multipatterning of gold nanoparticles (GNPs) around cells, sensing and actuating elements can be introduced in the cells' microenvironment, providing a powerful substrate for cell studies. In this work, a combination of techniques are implemented to engineer complex substrates for cell studies. Alternating GNPs and bioactive areas are created with micrometer separation by means of a combination of vacuum soft-lithography of GNPs and protein microcontact printing. Instead of conventional microfluidics that need syringe pumps to flow liquid in the microchannels, degas driven flow is used to fill dead-end channels with GNP solutions, rendering the fabrication process straightforward and accessible. This new combined technique is called Printing and Vacuum lithography (PnV lithography). By using different GNPs with various organic coating ligands, different macroscale patterns are obtained, such as wires, supercrystals, and uniformly spread nanoparticle layers that can find different applications depending on the need of the user. The application of the system is tested to pattern a range of mammalian cell lines and obtain readouts on cell viability, cell morphology, and the presence of cell adhesive proteins.
Outreach

GUIDED VISITS AT CIC BIOMAGUNE

The BNP Lab members, and particularly Ana Sánchez and María Sanromán, actively participate at CIC biomaGUNE visits program from high-school and university students. These visits typically include a lecture about biomaterials in the context of life sciences, an open discussion with researchers of the Centre, and a guided visit to six technical facilities/laboratories (Nanoparticle synthesis platform, Confocal microscope, Radiochemistry platform, Molecular Imaging Facility, Scanning Electron Microscope, Atomic Force Microscope).

- January 2016. Visit from 2nd year Biosanitary Baccalaurate students from St. Patrick’s English School
- March 2016. Visit from UPV-EHU Biotechnology -Molecular Biology and Biochemistry students
- March 2016. Visit from SUMMA Aldapeta high school students
- March 2016. Visit from 3rd year Food Science and Technology UPV-EHU students (organized together with DIPC)
- October 2016. Visit from pathological anatomy students from Instituto Easo vocational training centre. This visit was in the frame of the Donostia WeekINN (Innovation Week).
- December 2016. Visit from Arratia BHI high school students from Igorre.

URBANZIENTZIA

Several members of the BioNanoPlasmonics Laboratory (Susana Carregal, Judith Langer, Malou Henriksen, Marta Sanz, Leonardo Scarabelli, María Sanromán) actively participated at the Olatu Talka UrbanZientzia (Urban Science) event organized at San Sebastián by giving an interactive talk entitled “Rincón de la ciencia casera”.

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OUTREACH

PINT OF SCIENCE
The BioNanoPlasmonics Laboratory actively participated at Pint Of Science-Donostia 2016. This initiative brings Science to local bars, thereby breaking down the barriers that separate science from society.

MEDIA
Some examples of appearances in the media during 2016:

- December 2016. Luis Liz-Marzán Interviewed at the Galician TV, V Televisión in the frame of the program "Más que contar". Link
Scientific Collaborations

- Nanoparticle Synthesis and SERS Biodetection  
  Isabel Pastoriza-Santos / Jorge Perez-Juste - Colloid Chemistry Group, University of Vigo, Spain
- Electron Tomography and EELS Plasmon Mapping  
  Sara Bals / Staf van Tendeloo - EMAT, University of Antwerp, Belgium
- Plasmonics Modeling  
  F. Javier Garcia de Abajo - Nanophotonics Theory Group, Institute of Photonic Sciences, Barcelona (ICFO), Spain
- Interaction of Nanoparticles with Biosystems  
  Wolfgang Parak - Biophotonics Group, Philipps University of Marburg, Germany
- Nanoparticle Synthesis  
  Horst Weller - Institute of Physical Chemistry, University of Hamburg, Germany
- Plasmon Mapping by EELS  
  Mathieu Kociac - STEM/LPS (CNRS), Orsay, France
- Single particle spectroscopy  
  Natalia del Fatti / Fabrice Vallee - FemtoNanoOptics group - ILM Universiti© Lyon 1, CNRS, Lyon, France
- Mesoporous Materials  
  Paula Angelome / Galo Soler-Illia - Instituto de Nanociencia y Nanotecnologia, Centro Atomico Constituyentes (CNEA), Argentina
- Plasmonics and self-assembly  
  Yuebing Zheng - Department of Mechanical Engineering, University of Texas at Austin
- Cancer diagnostics  
  Charles Lawrie - Oncology Area, Biodonostia, San Sebastian
- Microfluidics  
  Lourdes Basabe-Desmonts - Microfluidics Group, University of the Basque Country, UPV-EHU
- Self-assembly  
  Andres Guerrero-Martinez - Nanochemistry Group, Complutense University of Madrid
- Large-Scale Plasmonics Modeling  
  Fernando Obelleiro – Departamento de Teoría de la Señal, University of Vigo, Spain
  José Manuel Taboada – Departamento de Tecnología de Computadores y Comunicaciones, University of Extremadura, Spain
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