Sputter-deposited Nanocolumns: Tuning Fe and Au Properties for In Vitro Biomedical Applications

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Motivation

Sputtering is a widely used technique in industry for the production of homogeneous thin films. The versatility of this technique also enables the growth of nanocolumnar structures to be made of a variety of materials by tilting the substrate during atomic deposition [1]. The nanostructuring of Au facilitates the development of systems that exhibit a Localized Surface Plasmon Resonance (LSPR), which enables their application in photothermal therapy, as well as the integration of Fe allows for the creation of hyperthermic agents [2]. The strategic combination of both materials yields a synergetic system that is highly advantageous for various biomedical applications, as well as in magnetoplasmonics [3].

Objectives

Four morphologies of Au and Au/Fe nanocolumns (NCs) have been grown on a silicon substrate: i) **Au tilted NCs**, ii) **Au vertical NCs**, iii) **Fe tilted NCs on Au tilted NCs** and iv) **Au tilted NCs on Fe tilted NCs**. The nanocolumns have been extensively characterized through **SEM** (morphological characterization), **XRD** (structural characterization at the European Synchrotron Radiation Facilities, ESRF), **reflectivity** (plasmonic studies) and **VSM** (magnetic characterization). Most importantly, **viability** and **adhesion** measurements have been carried out to determine if these systems are suitable for *in vitro* studies for biomedical applications, which is the main objective of this work.

Growth of the nanocolumns: MS-GLAD

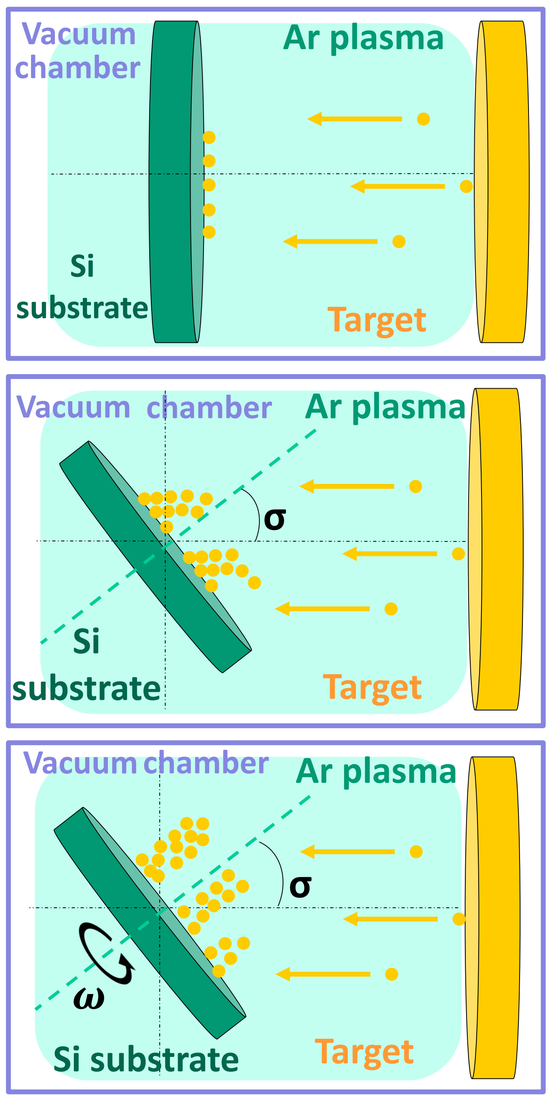
Thin films

+ tilt of substrate (σ)

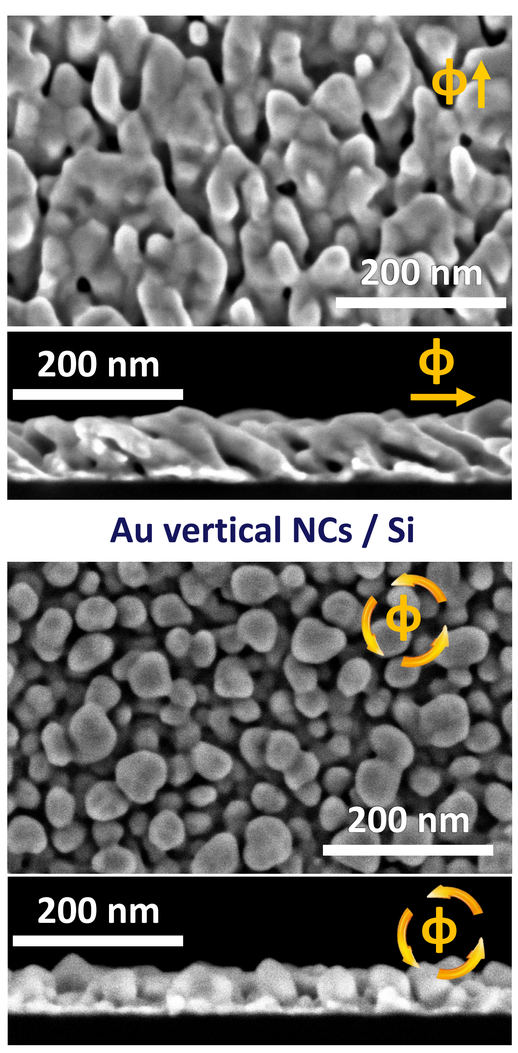
Tilted NCs

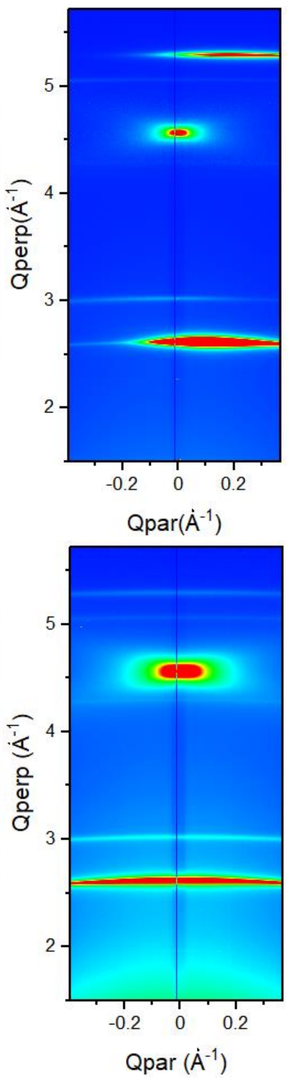
+ rotation of substrate (ω)

Vertical NCs



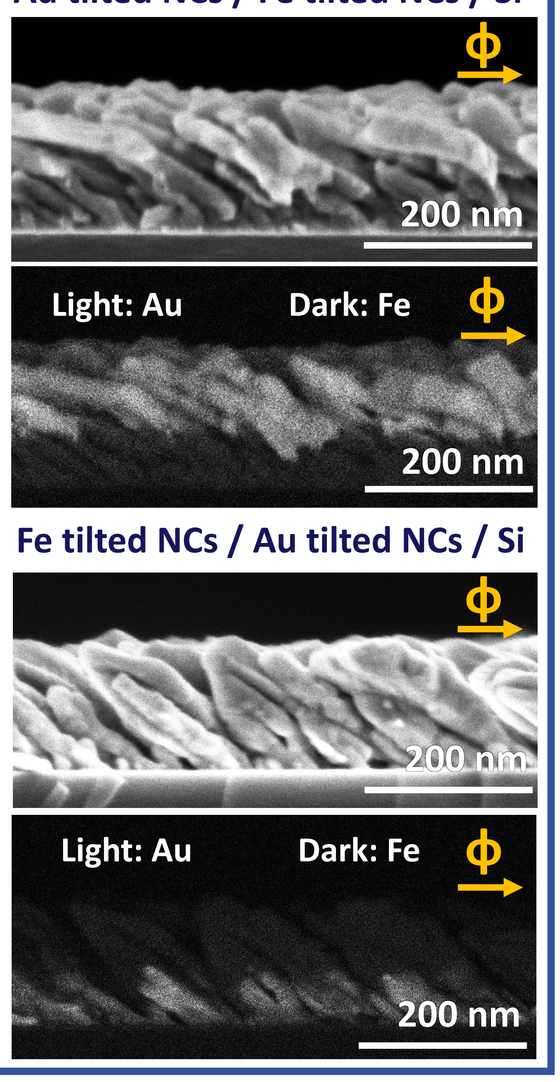
Morphological and structural characterization: SEM & XRD (ESRF)





SEM images show differences among vertical and tilted NCs. Also, in the bimetallic systems, backscattered electrons show the difference between the materials used: Fe NCs (dark) and Au NCs (light).

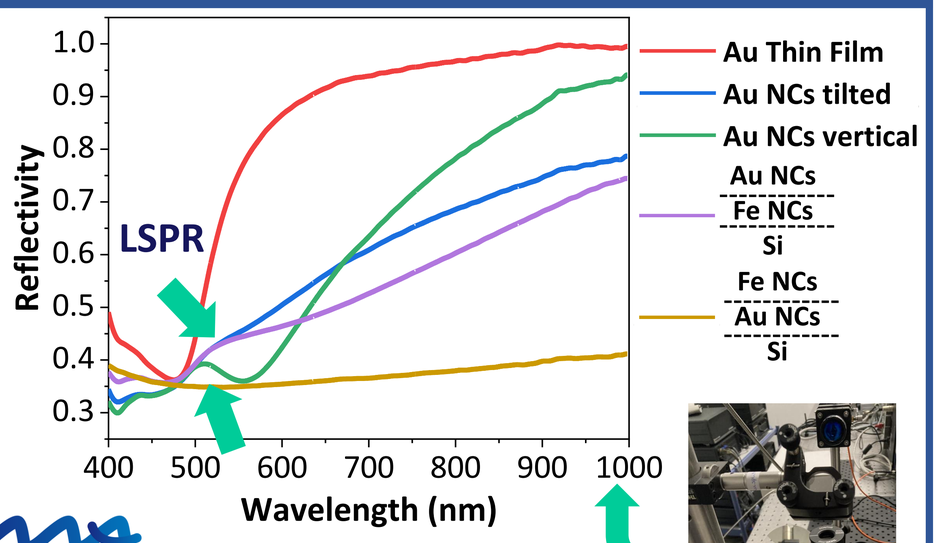
Vertical and tilted NCs give rise to different structural texture. Although both Au tilted and vertical NCs are polycrystalline, the tilted NCs are more textured.

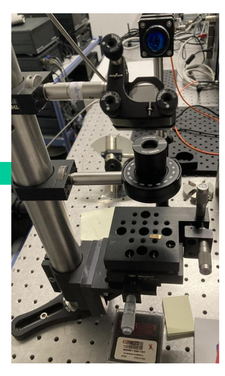


Magnetic and optical characterization: VSM & reflectivity

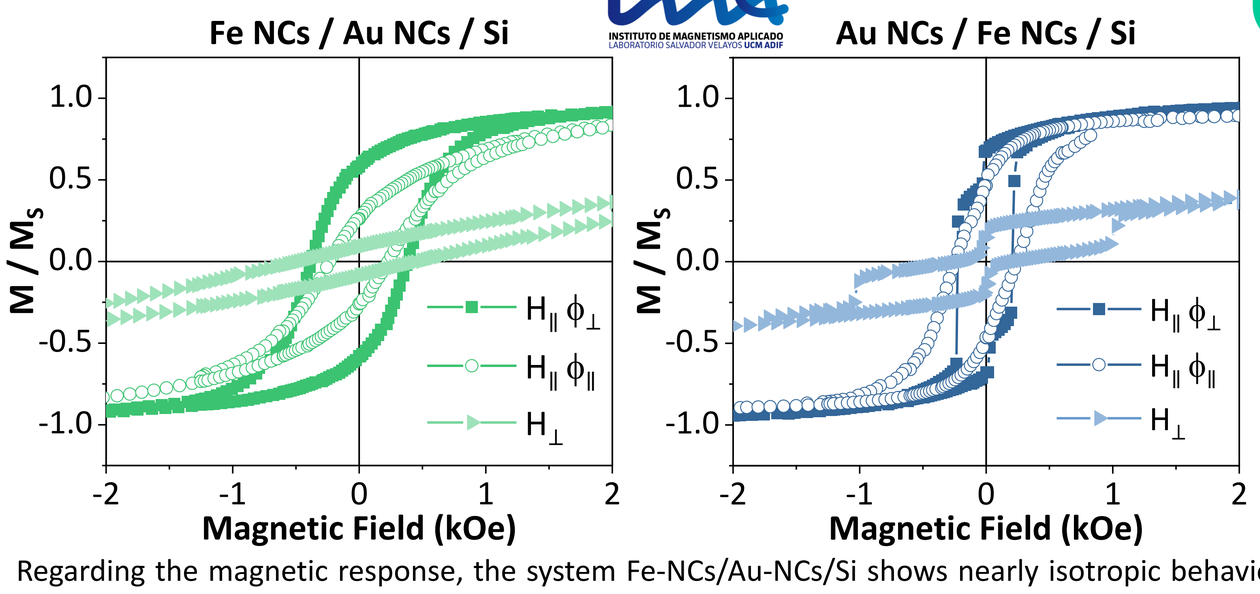
Optical properties (0° polarization)

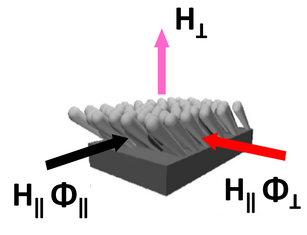
Reflectivity measurements demonstrate optical activity in all samples with Au NCs deposited on the top.—Among these, the **vertical NCs** and the bimetallic **Au-NCs/Fe-NCs/Si** system display a **LSPR** peak centered around 500 - 530 nm, being notably more pronounced in the sample containing vertical NCs. The presence of LSPR allows the use of these samples in photothermal treatments.





Magnetic measurements (VSM)

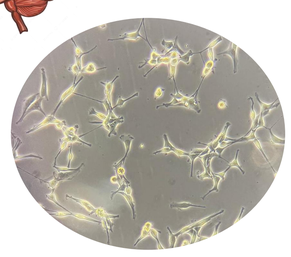




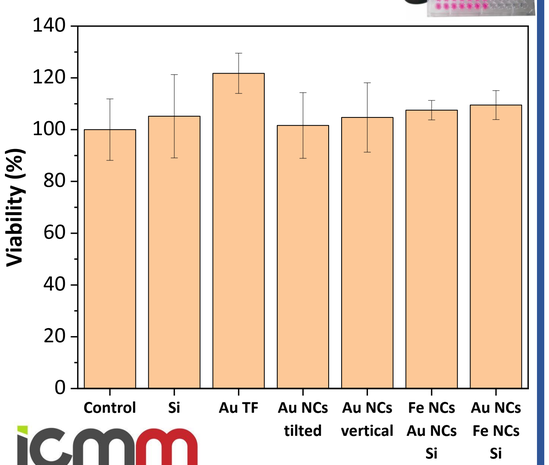
Regarding the magnetic response, the system Fe-NCs/Au-NCs/Si shows nearly isotropic behavior. On the other hand, Au-NCs/Fe-NCs/Si configuration shows different magnetic responses depending on the direction of the applied magnetic field because of a **uniaxial magnetic anisotropy** induced by GLAD growth [4]. The presence of a sharp change (or "jump") in the magnetization curve when the magnetic field is applied perpendicular to the substrate demonstrates the existence of another magnetization easy-axis, which is due to an interface **Au/Fe anisotropy.**

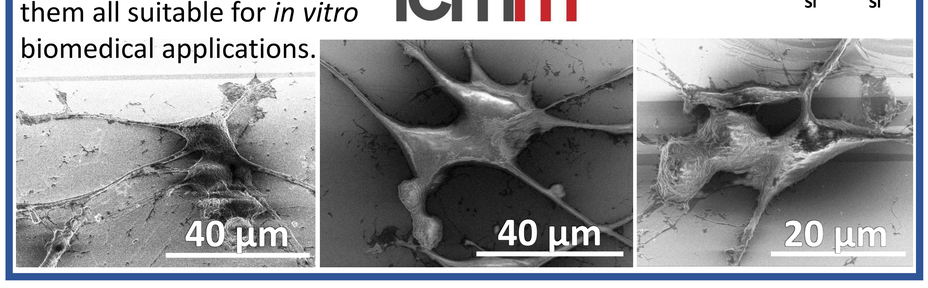
Viability and celular adhesion

U87 glioblastoma cells



Viability and adhesion tests with U87 cells show high biocompatibility and adhesion with every substrate, which makes them all suitable for *in vitro* biomedical applications.





References

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Acknowledgements

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