

Rutile micro- and nano-structured obtained by ultrashort laser ablation of titanium in liquid

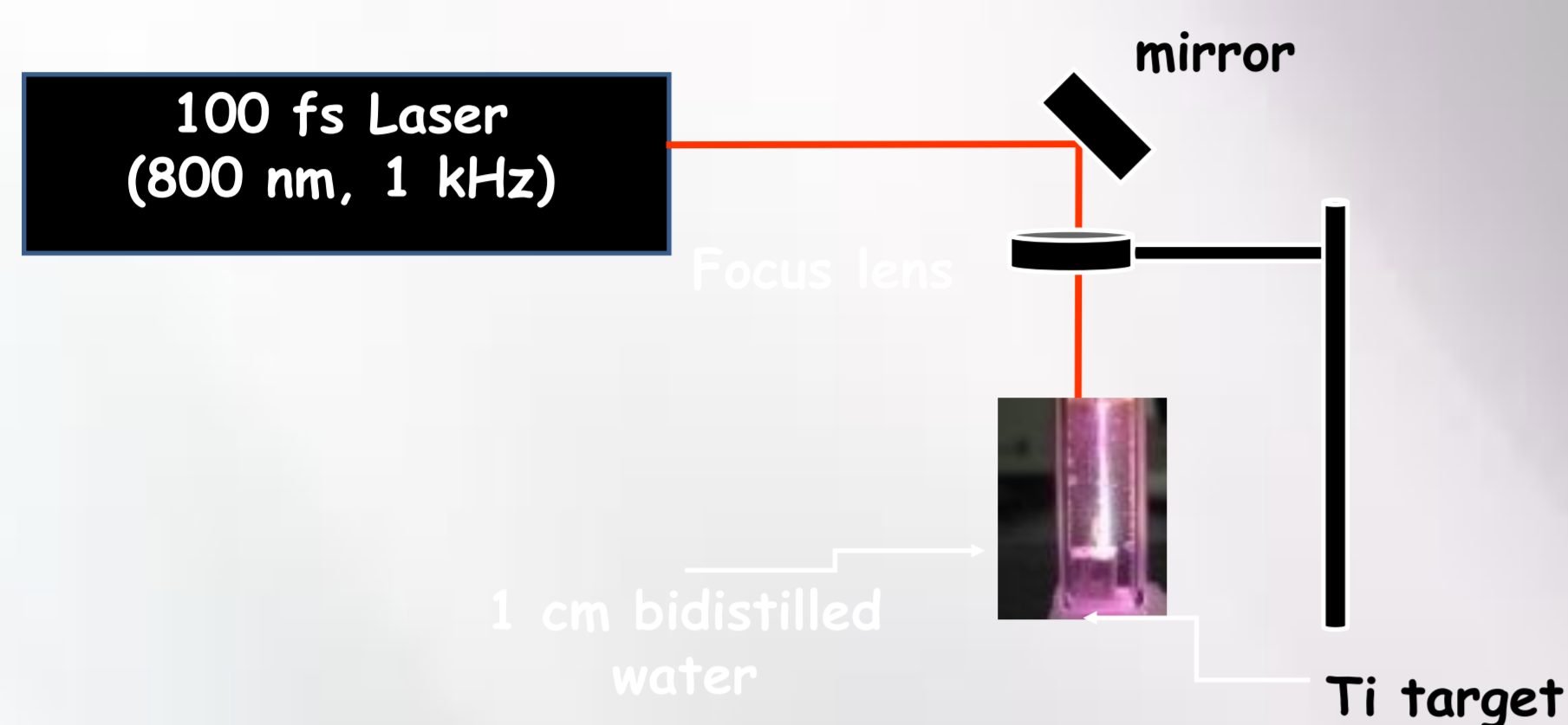
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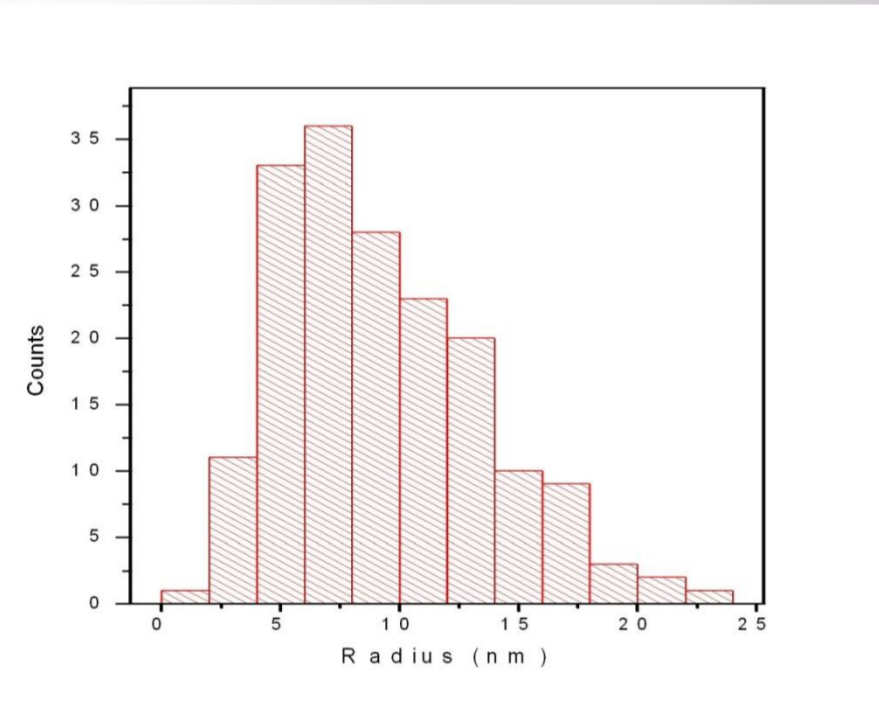
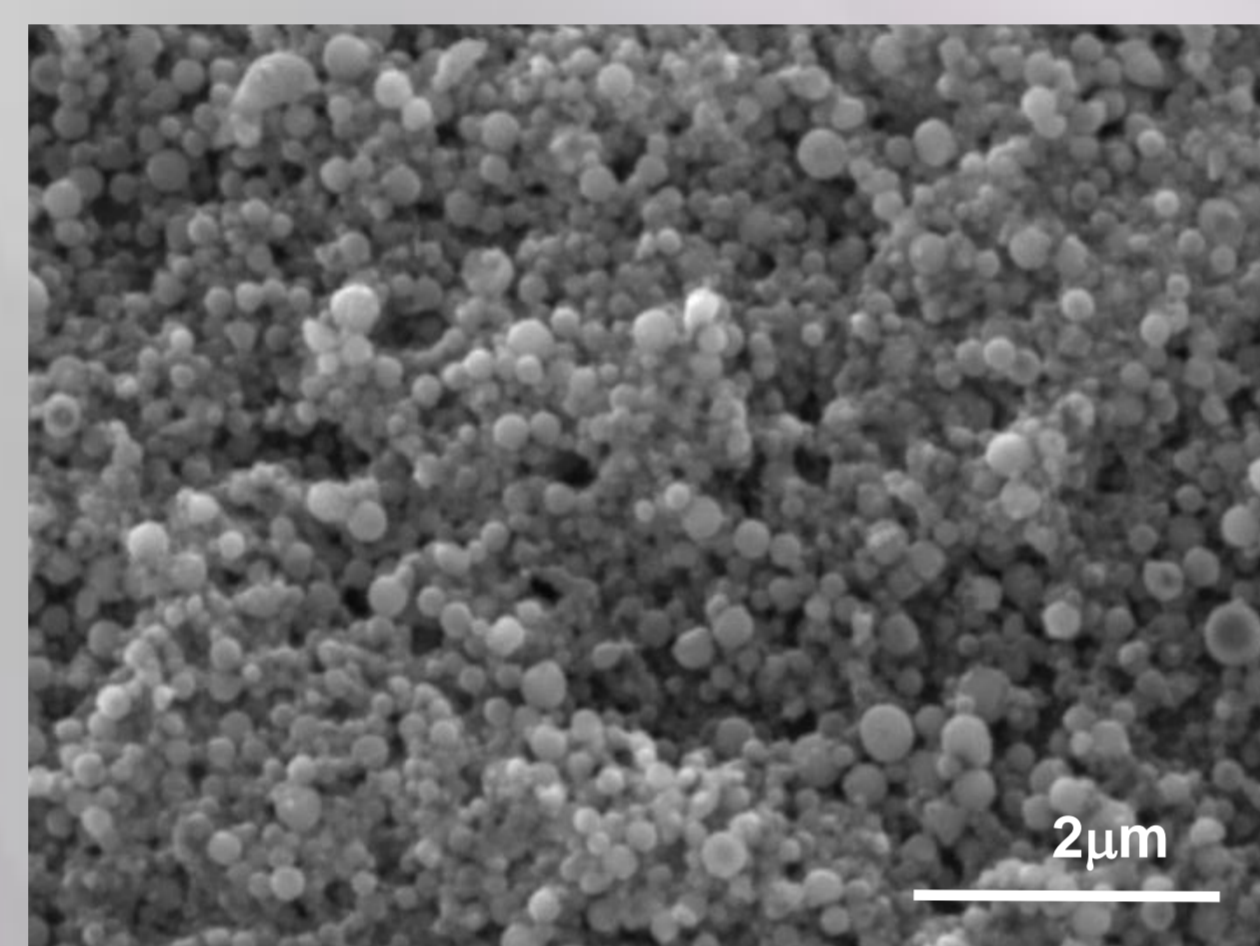
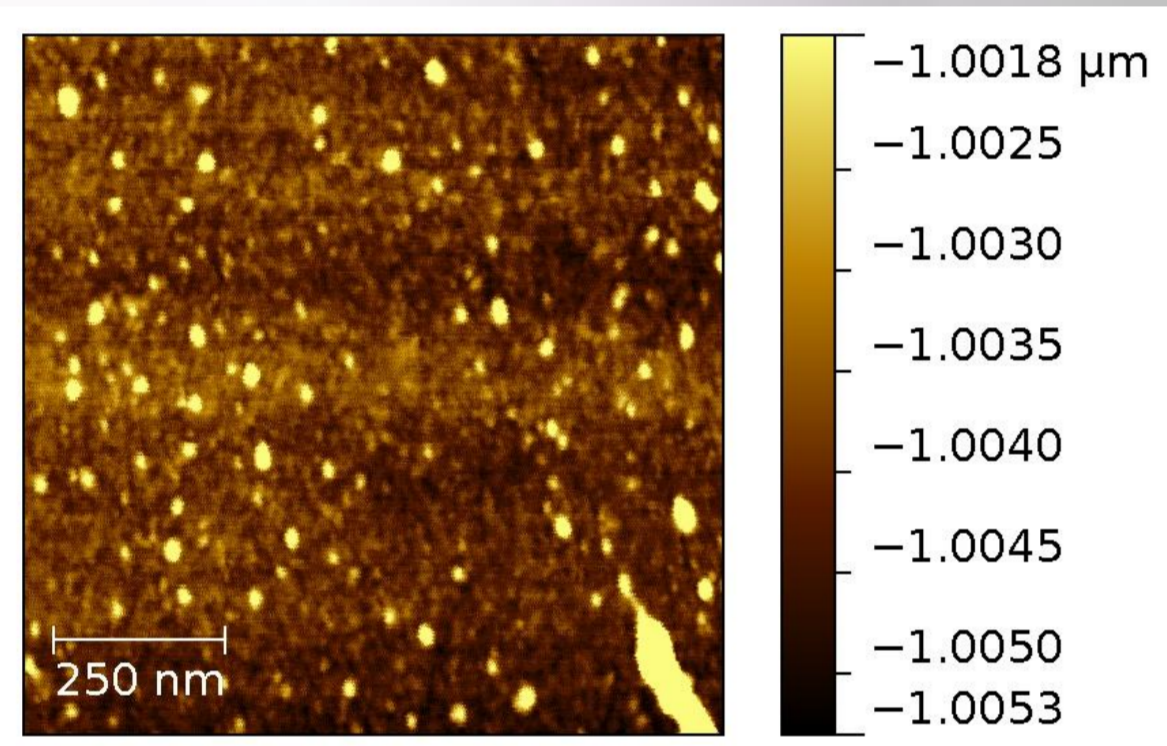
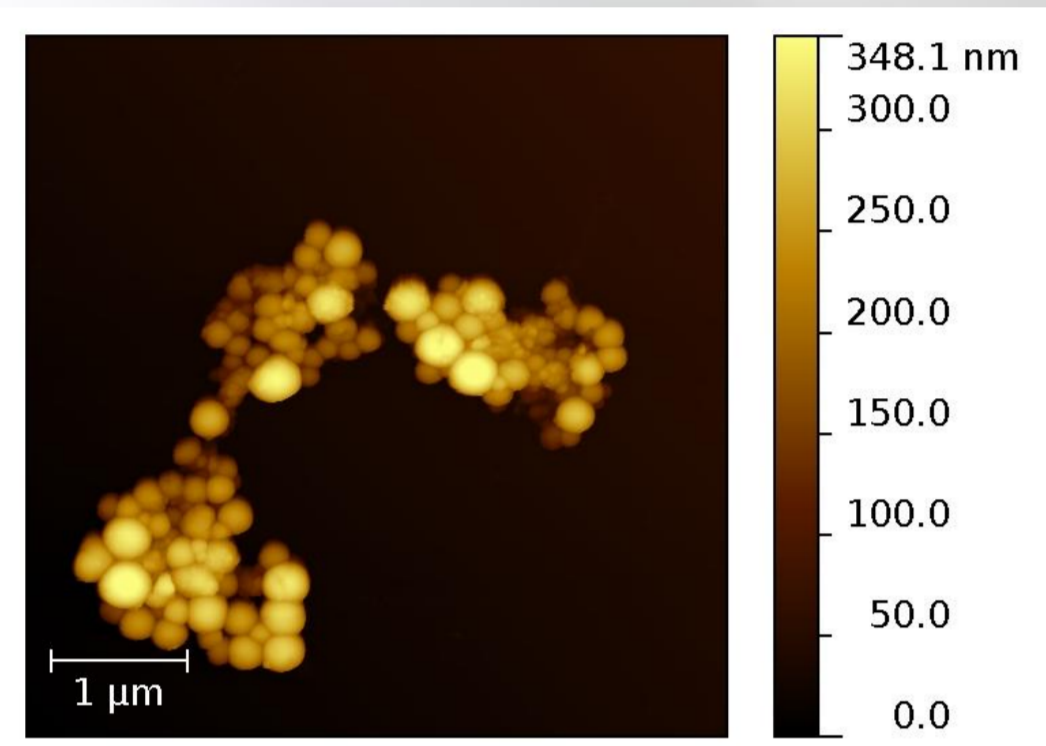
Laser ablation in water: Experimental set-up



ABSTRACT

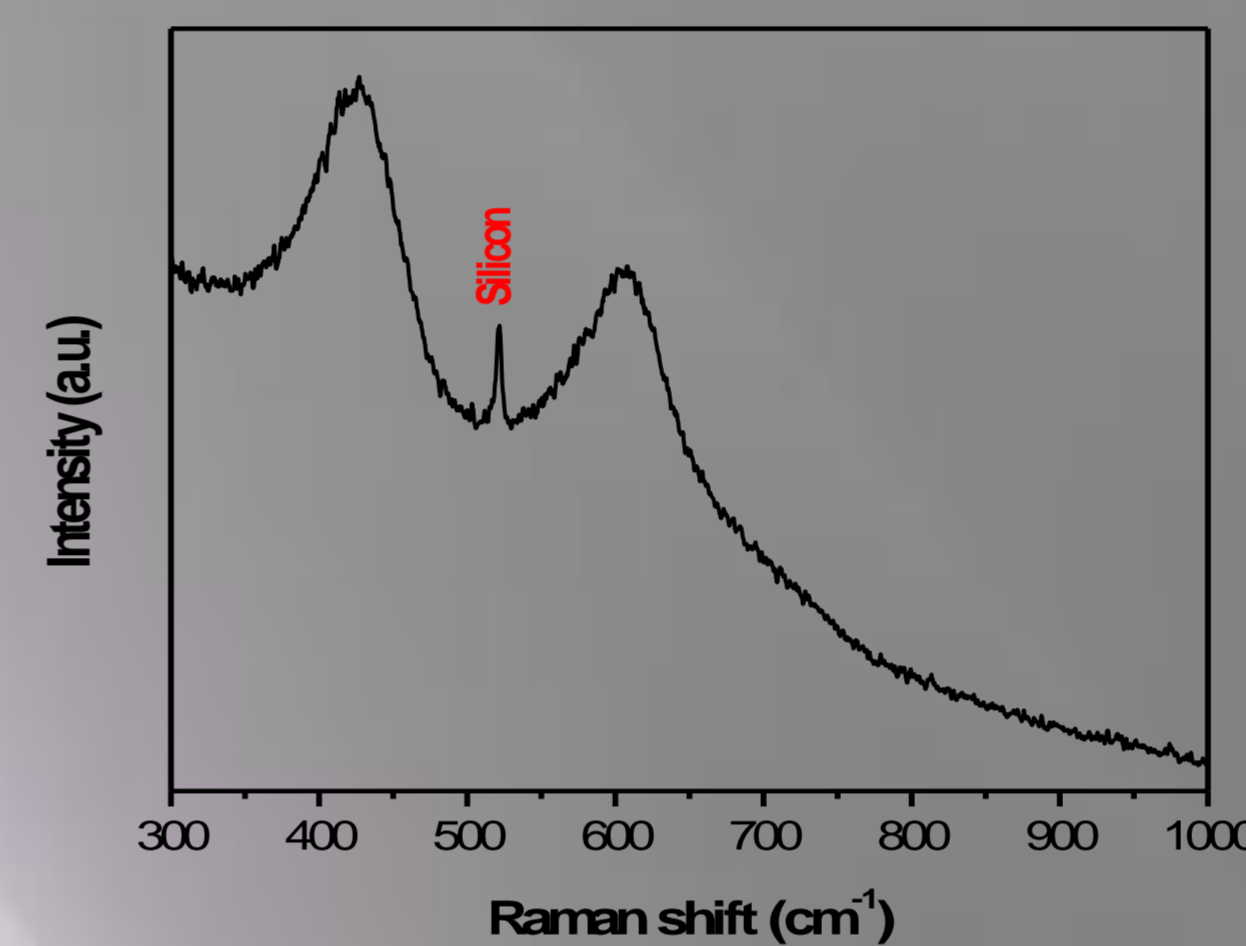
Fabrication of nanoscopic and microscopic hollow tubular structures have attracted significant interest due to their novel functions in the development of advanced devices. Among them metal oxide nanotubes are widely utilized as sensors and drug delivery systems, but microtubes with hollow interiors exhibit a better chemical stability and less obstruction of the interior cavity than their nanosized counterparts. Recently the possibility of obtaining microstructure by assembling nanoscale building blocks has been investigated. In this contest, we have produced titanium oxide nano-structures by ultrashort laser ablation of a titanium target in water. Laser pulse duration of 100fs (800nm, 1KHz) was applied. The obtained nano-structures have been observed and characterized by AFM, SEM, micro-Raman and micro-XRD. The nanoparticles have a mean diameter in the range of 20nm with a typical rutile crystal structure. Moreover, AFM images show the presence of nanowires with a diameter and length of tens and hundreds of nm, respectively. It is shown that the produced nanoparticles self assemble in liquid environment in form of microscopic tubular structures, preserving the rutile crystal phase.

Nanoparticles: morphology

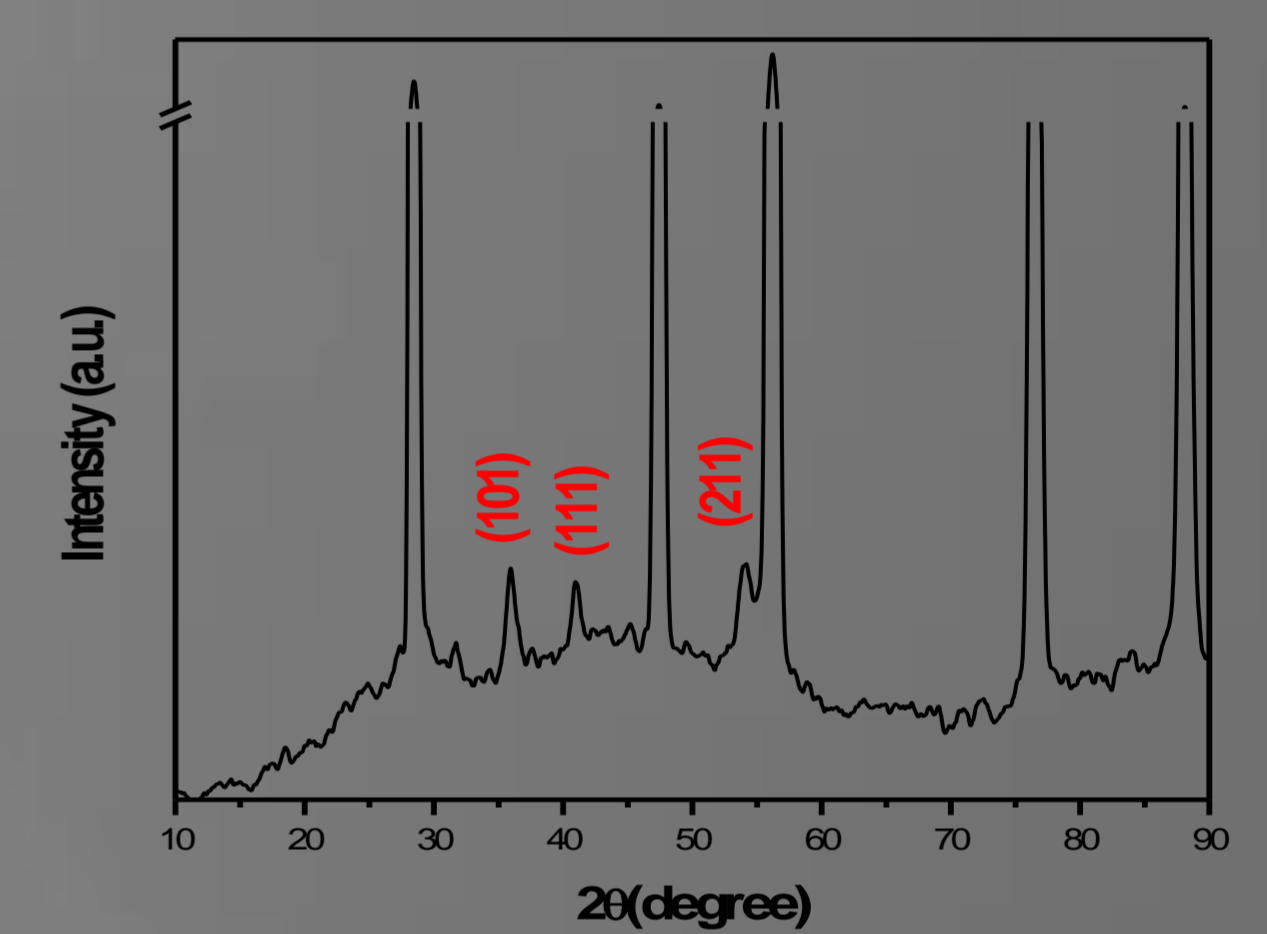


AFM and SEM images were registered depositing the colloidal solution onto silicon substrate immediately after the ultrashort laser ablation of titanium in water. AFM analysis evidence the presence of spherical nanoparticles with a mean diameter of 20nm.

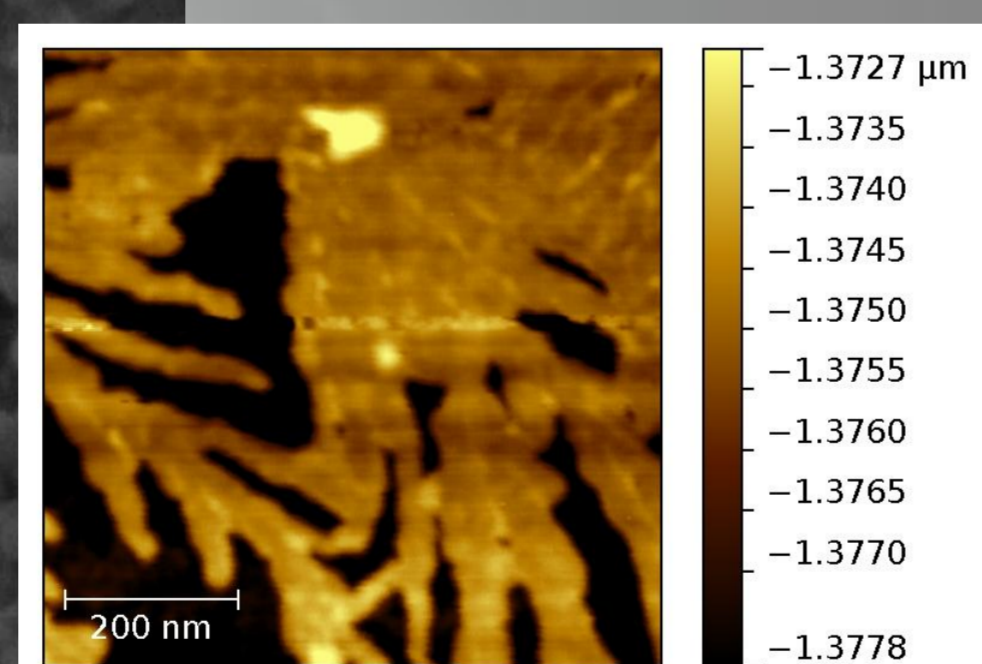
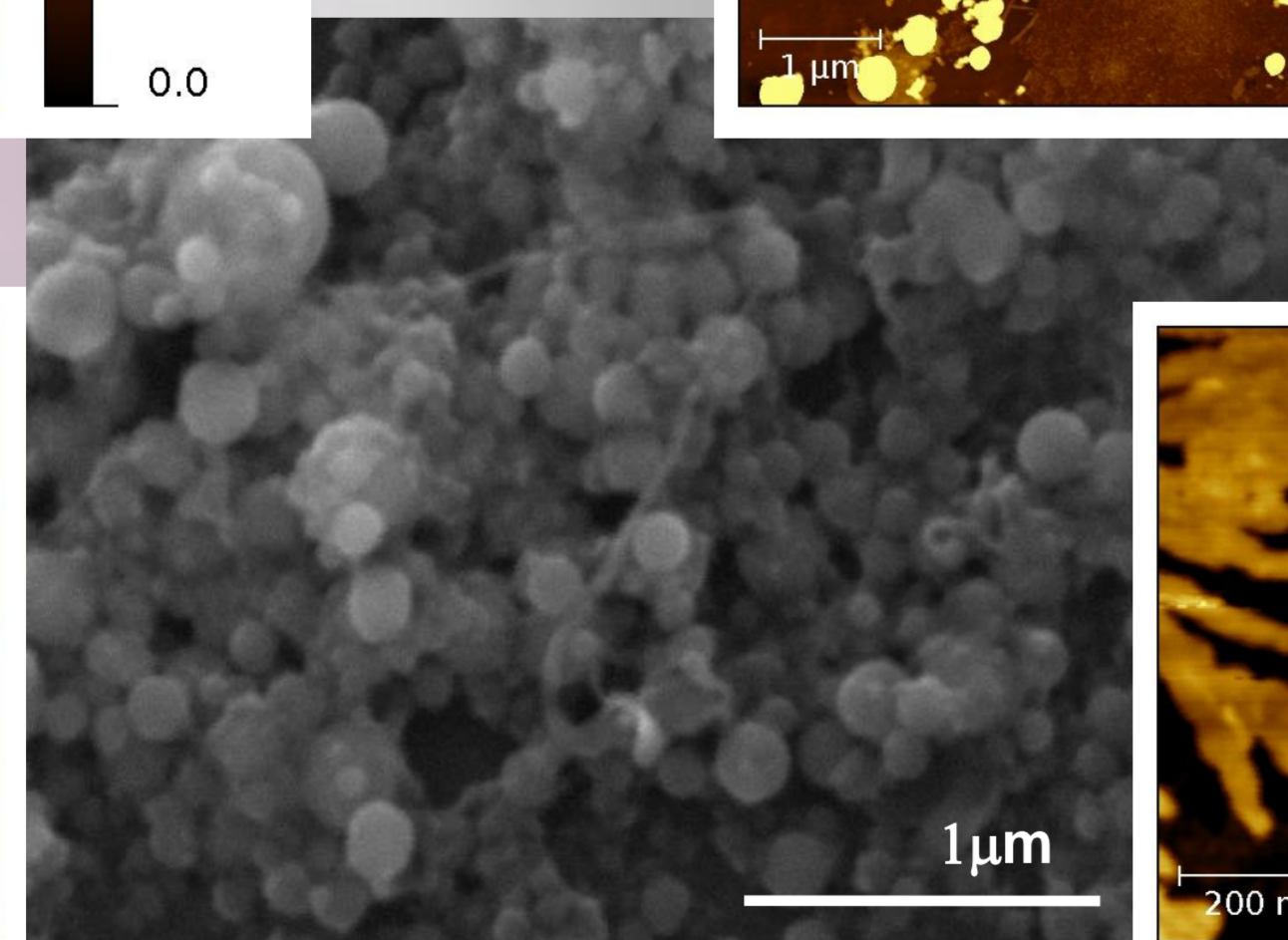
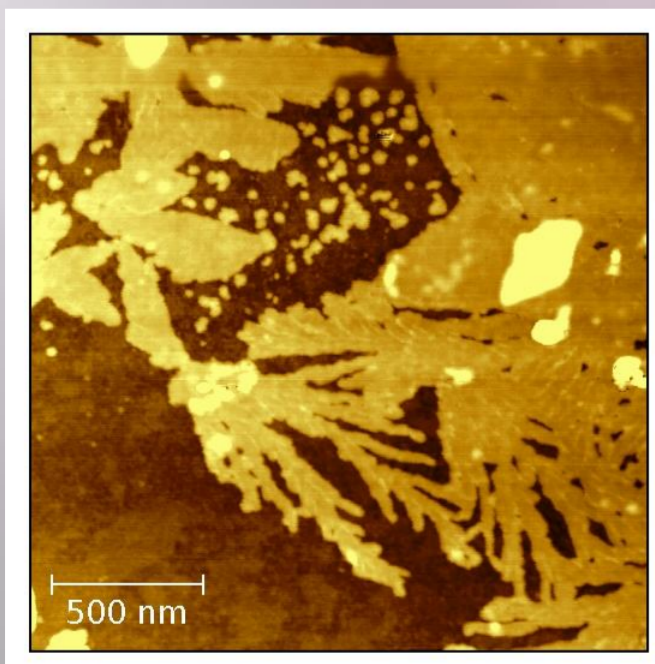
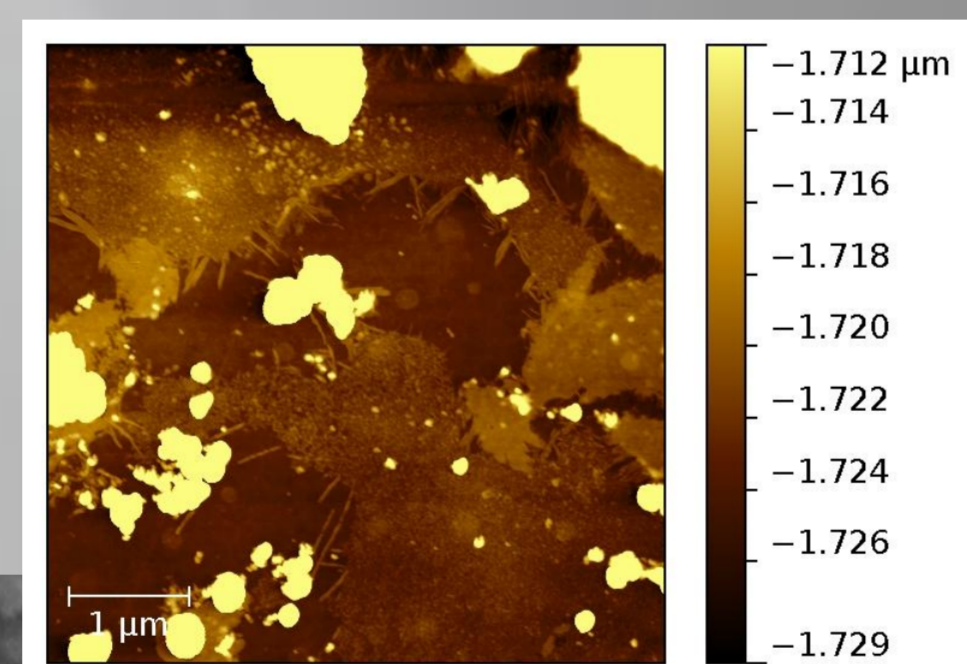
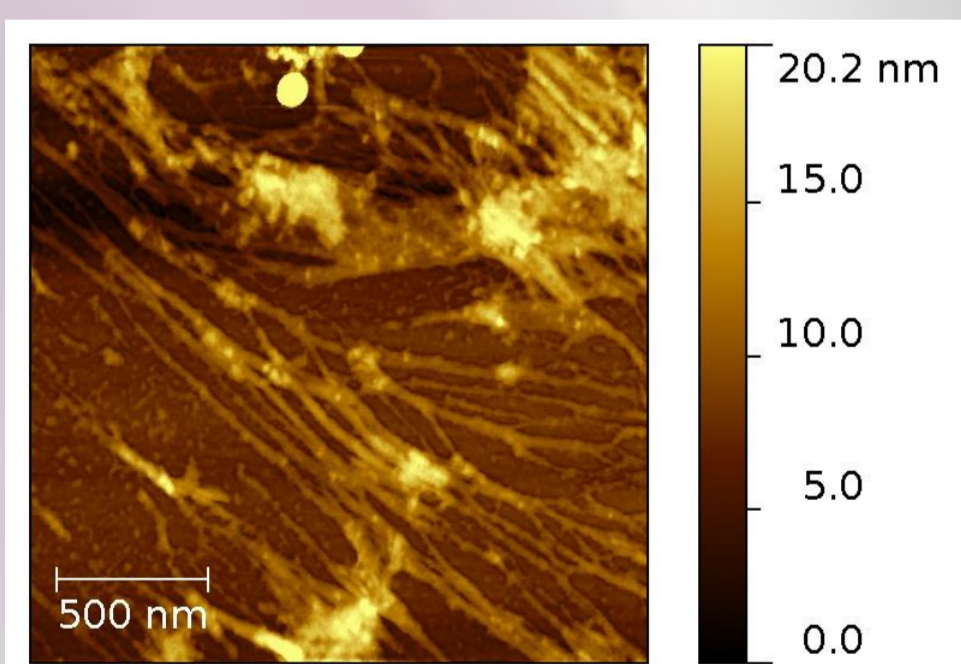
Micro-Raman and micro-XRD analysis of the nanoparticles



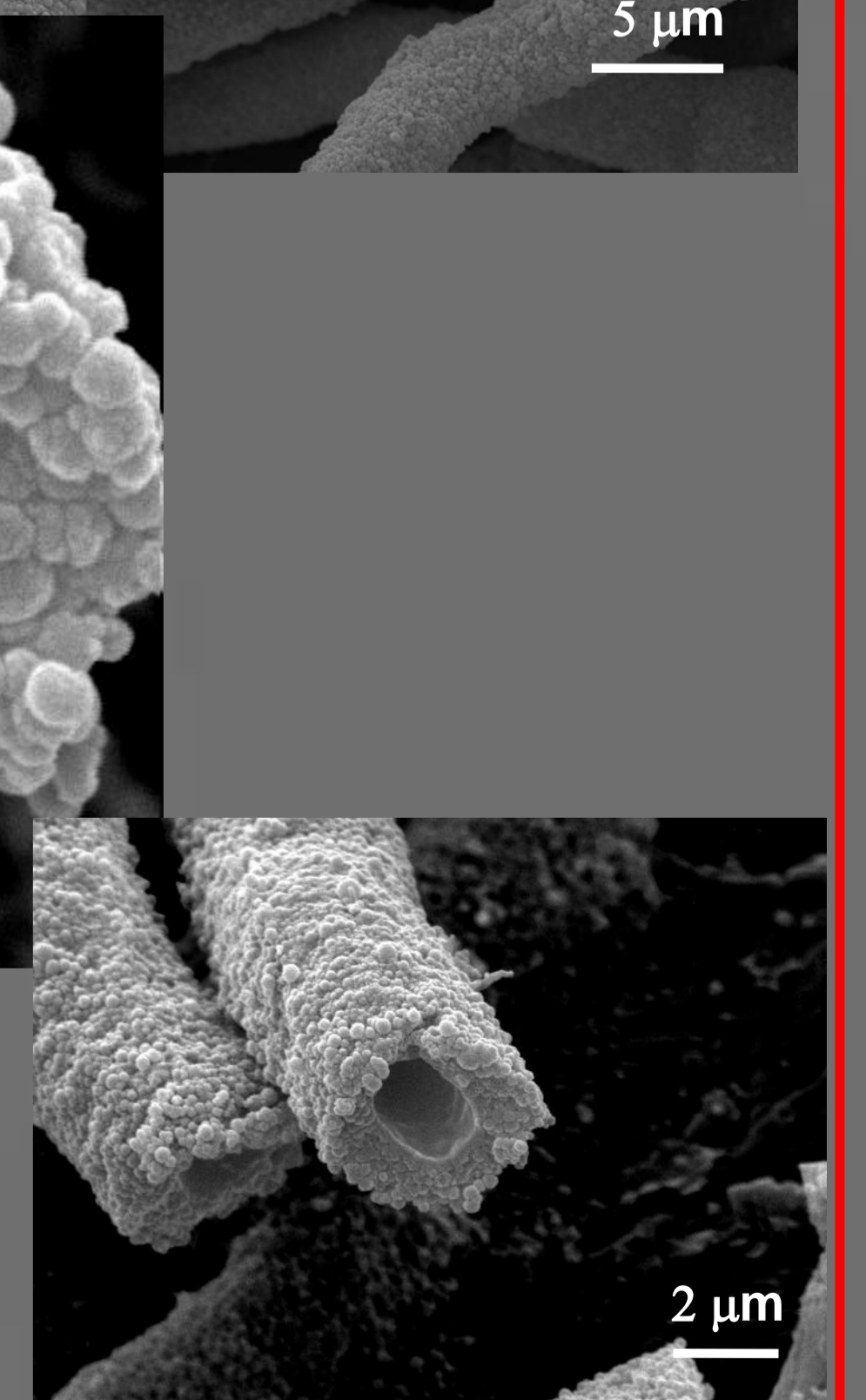
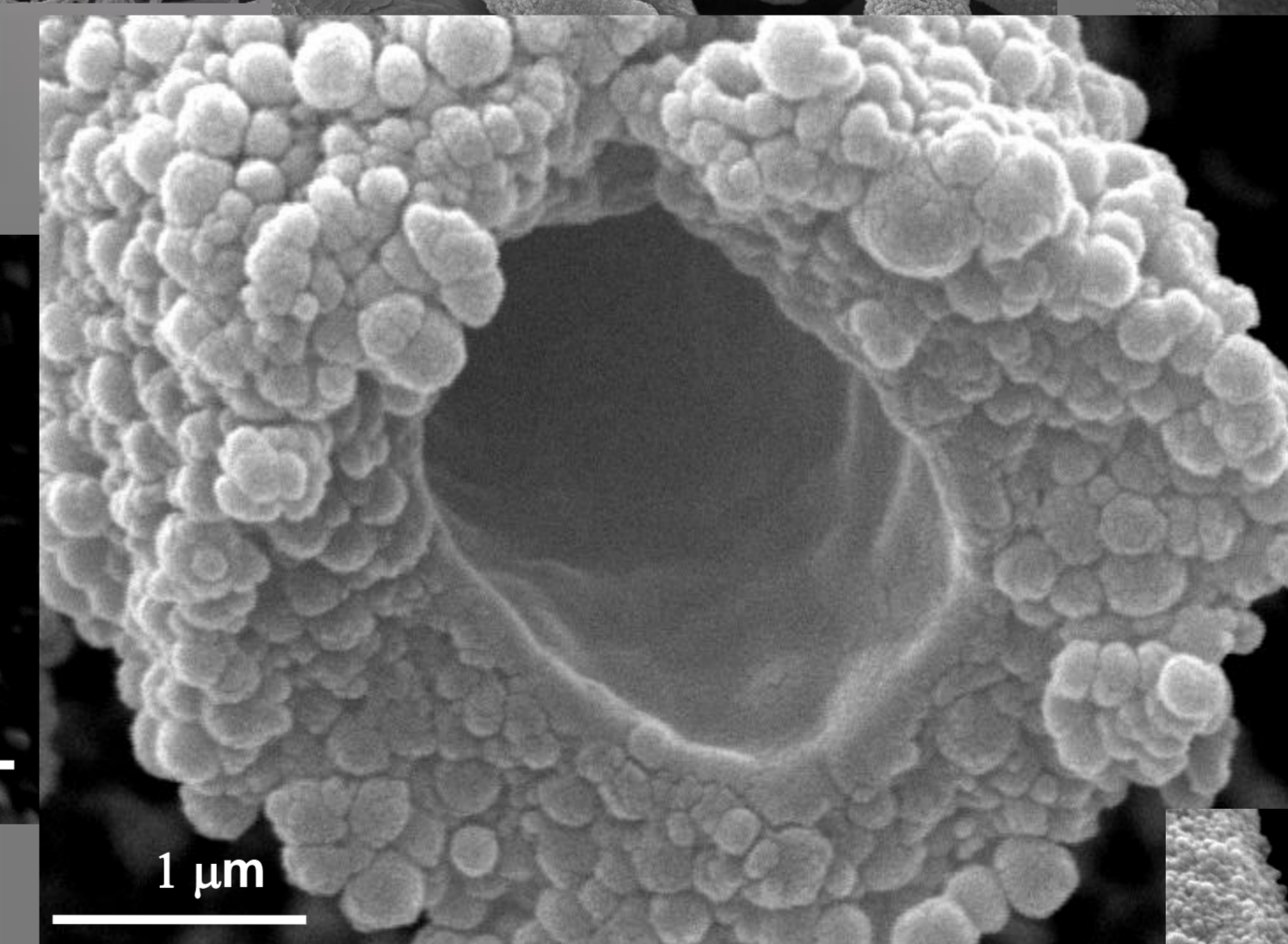
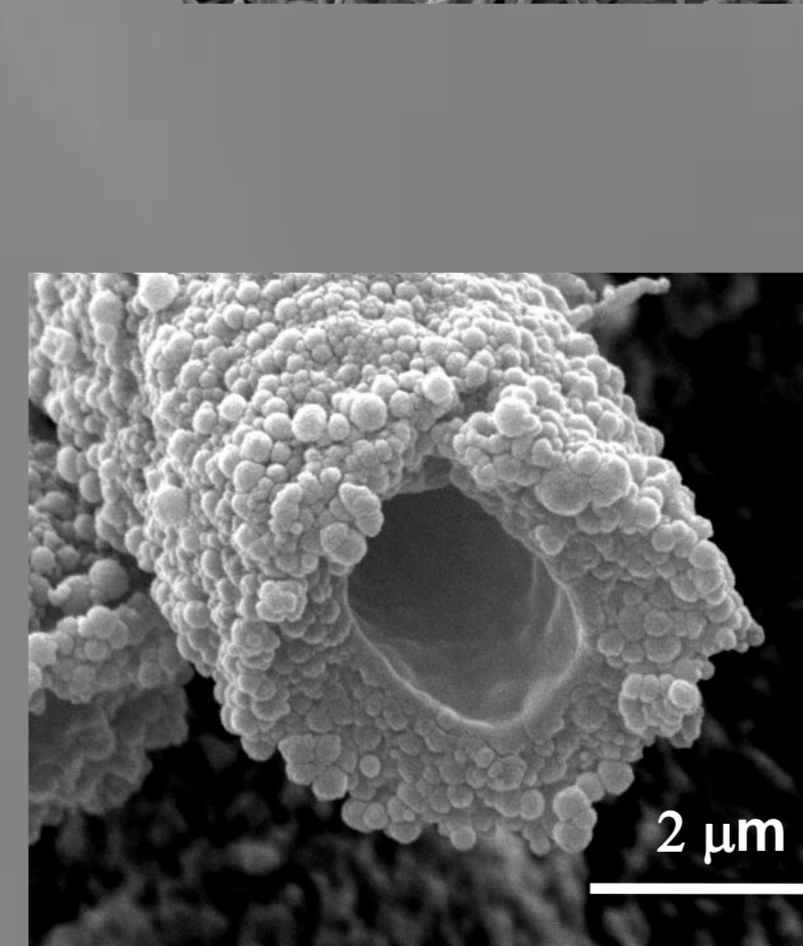
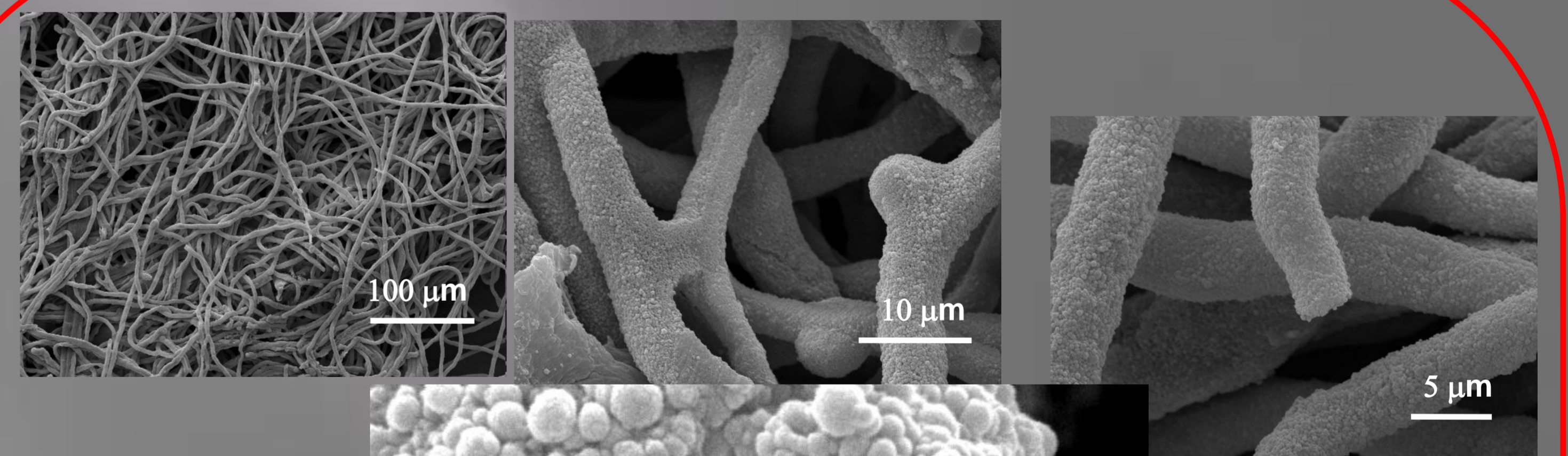
Raman spectrum (λ : 632.8nm) of the obtained nanoparticles presents two peaks at 426 and 608 cm^{-1} respectively. The observed red shift respect to rutile TiO_2 can be due to a phonon confinement effect related to the nanosize of the particles.



In XRD spectrum three peaks related to TiO_2 rutile structure are present.



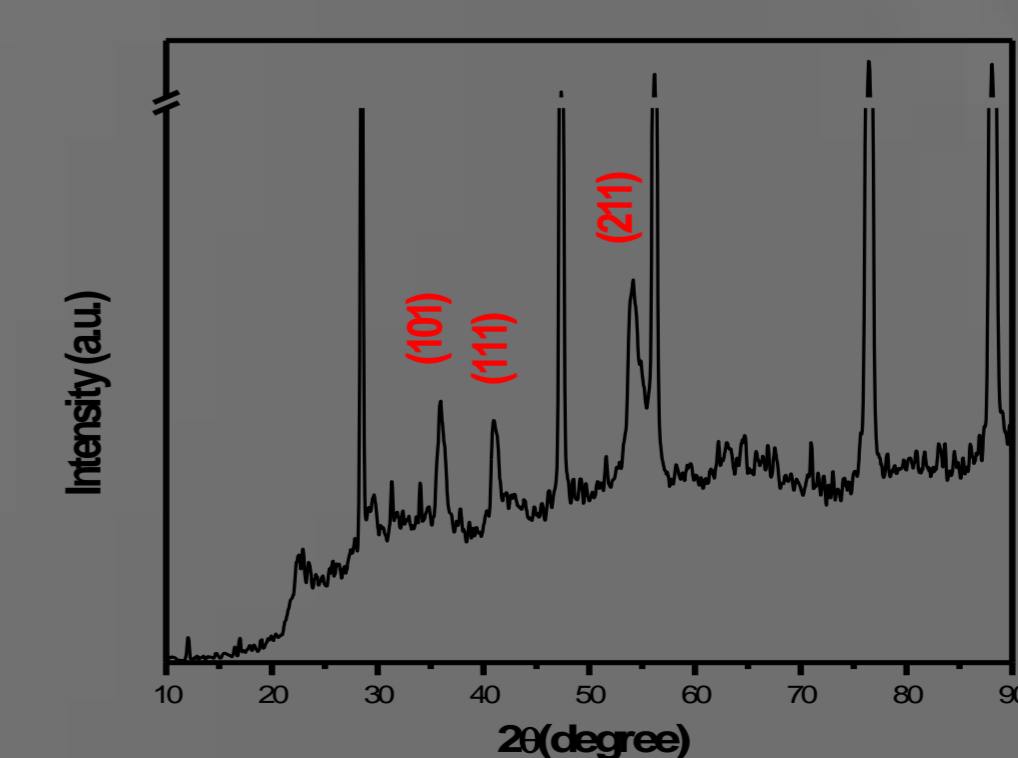
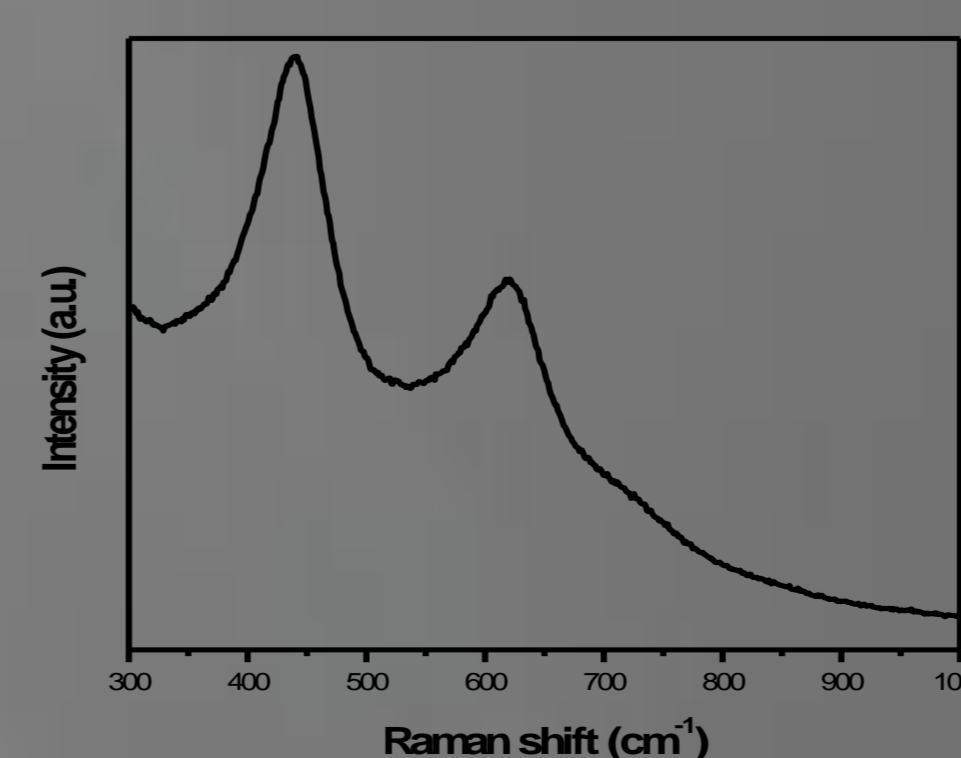
After about 120 h some nanostructure are formed in the colloidal solution. In particular AFM and SEM micrographies evidence the presence of nanowires with a diameter and a length of tens and hundreds of nanometer respectively.



Successively (after ca. 240 h), titanium oxide nanoparticles self assemble forming hollow microtubes with distinct internal/external morphology. The walls of these long tubular structures, formed by the aggregation of titania particles, are rough, whereas the internal surface is relatively smooth.

CONCLUSIONS

Titanium dioxide nanoparticles and nanostructures have been obtained by ultrashort laser ablation of a titanium target in water. Micro-Raman and micro-XRD analysis show that nanostructures present the tetragonal rutile structure. TiO_2 nano-structures self assemble, in liquid environment, to form long tubular structures with distinctive internal/external morphology features.



Micro-Raman and micro-XRD measurements confirm that microtubes are formed by titania nano crystals in form of tetragonal rutile structure.