Nano Innovation 2021 Rome, 21-24 September
Conference & Exhibition

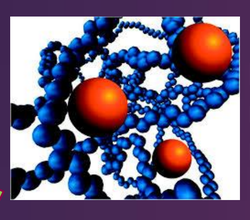
Laser synthesis of Silicon nanoparticles and surface functionalization for tuning luminescence

ENEA
Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile

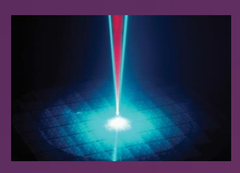
Rosaria D'Amato*[1], Stefania Dello Iacono[1,2], Antonino Santoni[1], Priscilla Reale[1], Francesca Limosani[1], Gaetano Terranova[1], Andrea Migliori[3], Sabina Botti[1], Francesca Bonfigli[1]
*rosaria.damato@enea.it

[1]ENEA, FSN-TECFIS-MNF, C.R. Frascati, [2]CNR-ISASI, Area di Ricerca di Napoli, [3]CNR-IMM, Area della Ricerca di Bologna

Silicon nanocrystals (SiNCs) are an extensively studied light-emitting material due to their inherent biocompatibility and compatibility with silicon-based technology. In this work, carried out in the wider framework of the NANOSCRILA project, granted by Regione Lazio, the development of SiNCs as the active materials for innovative LEDs was studied, exploiting the key role of NCs surface chemistry in the tuning of luminescence.



Photoluminescent nano-structured materials



Laser manufacturing

Nanoscrittura Laser di materiali compositi per la realizzazione di dispositivi luminosi a basso consumo

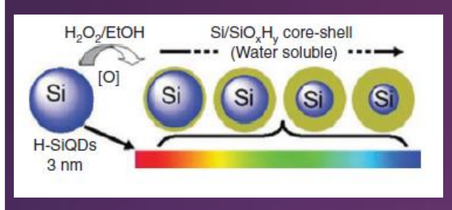
LCA

The project NANOSCRILA

Aim of the project is the development of active materials for innovative LEDs devices by using laser writing of quantum dots (QDs).
The tools for achieving our goal are novel luminescent nanocomposites and a ground-breaking methodology that employs laser light to induce the luminescence of the QDs.
The Key Enabling Technologies (KET), such as Nanotechnology and Advanced Materials, Photonics, Micro and Nano-Electronics and Advanced Manufacturing technologies, help to carry out our strategy.
The system is promising for bio-ecological and luminescent properties. Life cycle assessment (LCA) of synthetized materials and laser processes is essential for evaluating the potential environmental impacts

Silicon quantum dots

NANO-SILICON EMITTING IN THE VISIBLE ☺
Si SURFACE IS APT TO CHEMICAL FUNCTIONALIZATION ☺
COMPATIBILITY WITH ELECTRONIC TECHNOLOGY OF Si ☺
NON-TOXIC, CHEAP, ABUNDANT ☺



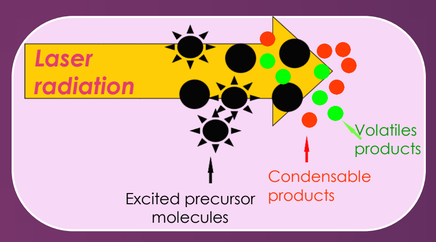
The optical emission properties are determined by a very complex interplay between the size dependent quantum confinement effect and the surface properties.

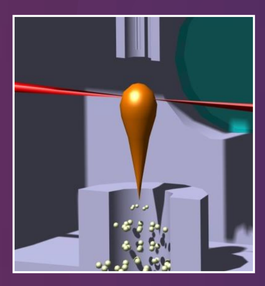
Laser synthesis of Silicon nanocrystals

$SiH_4 \rightarrow Si + 2H_2$

aggregates of nearly monodispersed and primary particles

CO_2 laser pyrolysis

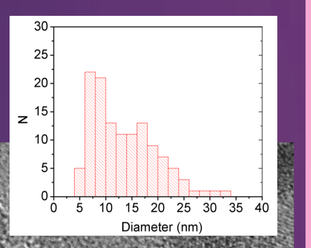


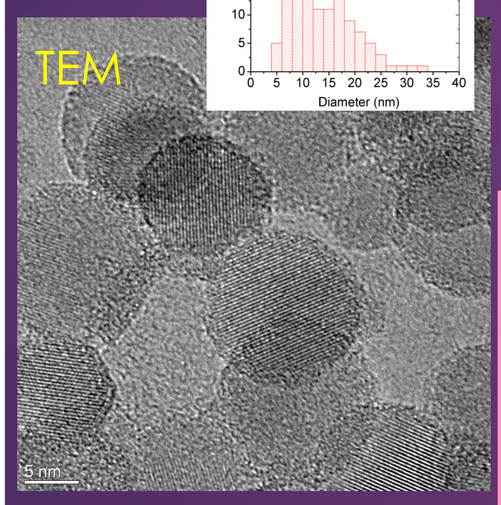


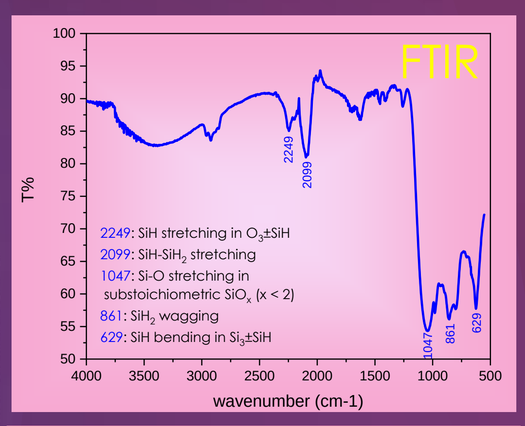
Synthesis conditions:
$\Phi(SiH_4)$=250 sccm;
$\Phi(C_2H_4)$=50 sccm;
P_{laser}=1200W
P = 60 torr

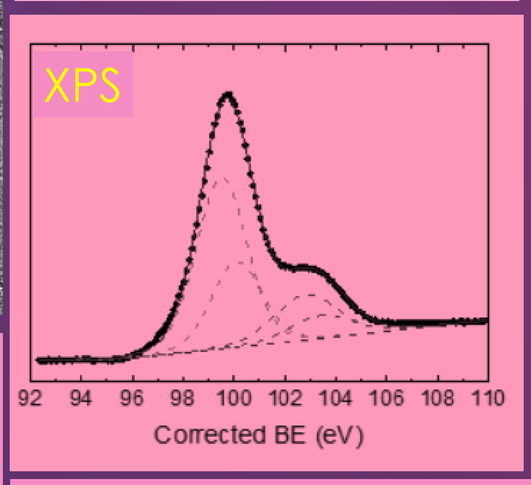
In this process the nucleation and growth of NPs result from laser induced chemical reactions at the crossing point of the laser beam with the molecular flow of gas or vapour–phase precursors. Produced NPs are: **spherical**, **monodisperse in size**, **almost pure**

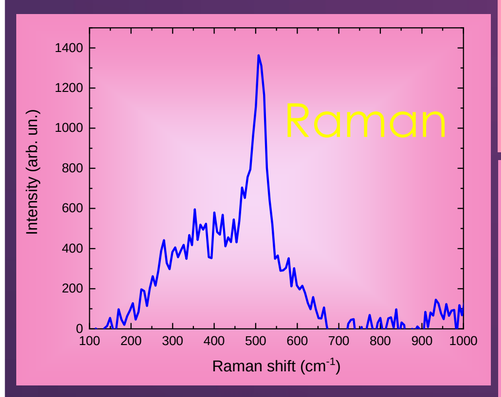
Characterization







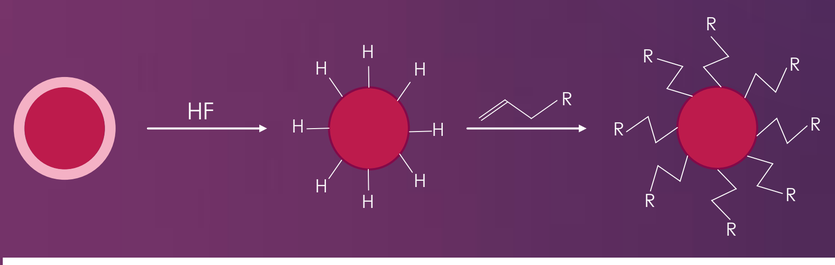


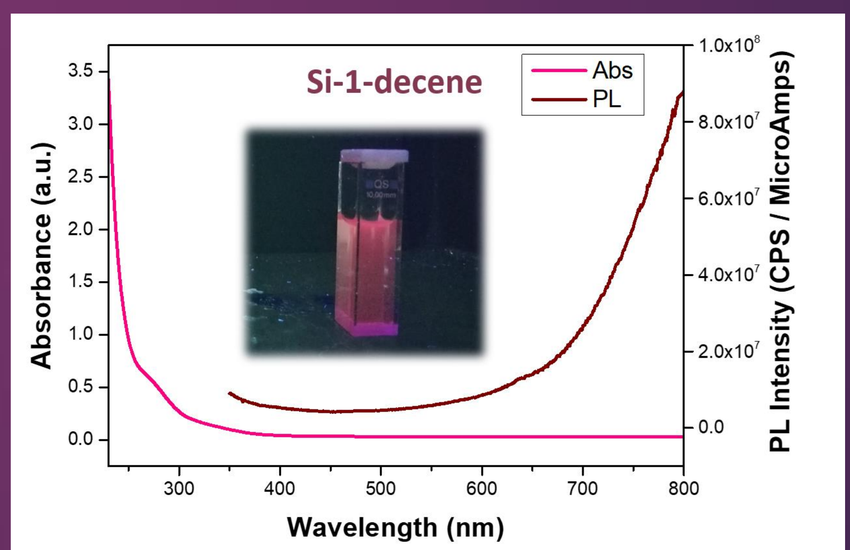


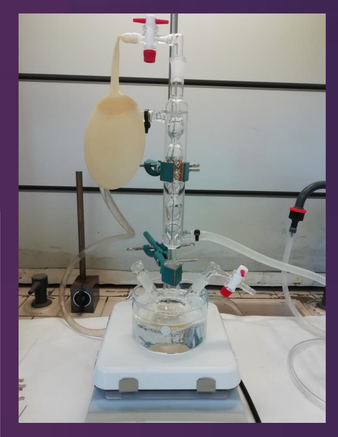
BET SSA = 170 m^2/g
d = 15 nm

Produced Si nanoparticles have a crystalline core, covered by an oxide layer, with hydrogenated surfaces, and estimated average diameter 13.0 nm, but with a good part of nanoparticles under 10 nm. They show very low luminescence.

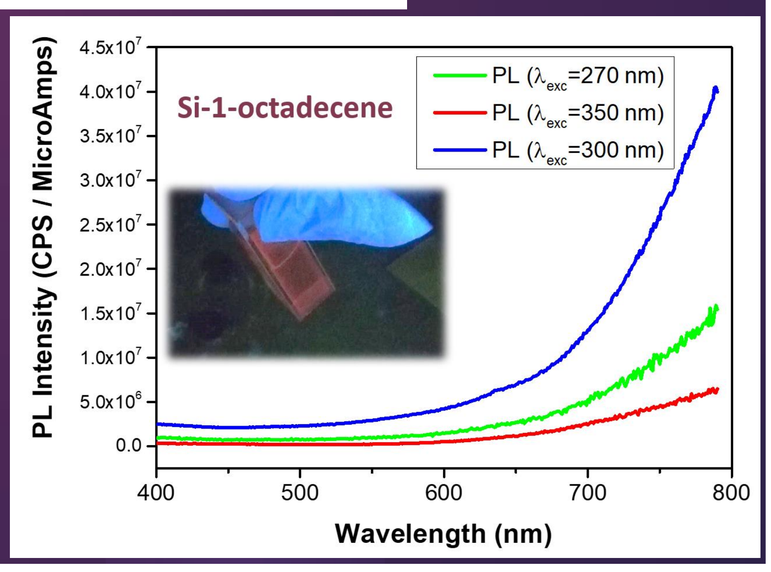
Surface functionalization







SiNCs with various surface functionalities, in particular 1-decene and 1-octadecene, were prepared by wet chemistry. A significant enhancement of the photoluminescence efficiency is observed.



Acknoledgement

NANOSCRILA

REGIONE LAZIO