Thesis subject :
SERS Spectroscopy for OPV characterization

Pavia, May 2020

Eni Donegani Institute

It is one of the oldest research centers in Italy.

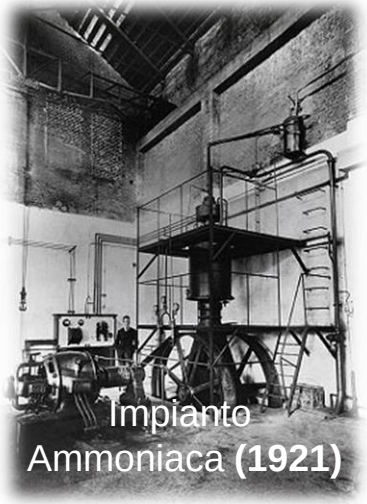
The history of the centre is strictly connected with the history of the industrial chemistry in Italy.

The Centre was build up in 1939-41, by the chemical company Montecatini, according to the President Guido Donegani and the scientist Giacomo Fauser.

The first research laboratory was built next to the Montecatini factory (1921), then expanded with the advent of ANIC in 1934.

G. Donegani, president of Montecatini, realized the new Institute, opened in 1942 under Fauser direction.

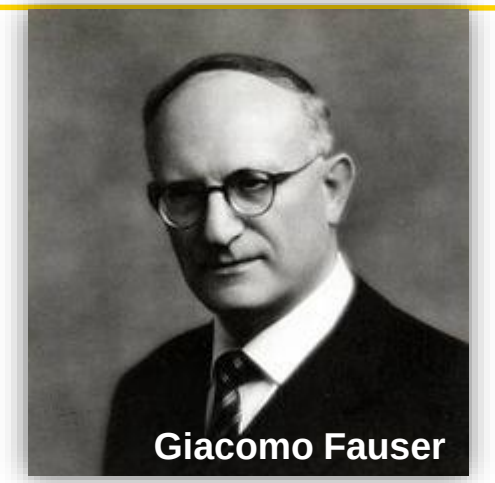
Istituto Guido Donegani (1951)



Impianto Ammoniaca **(1921)**

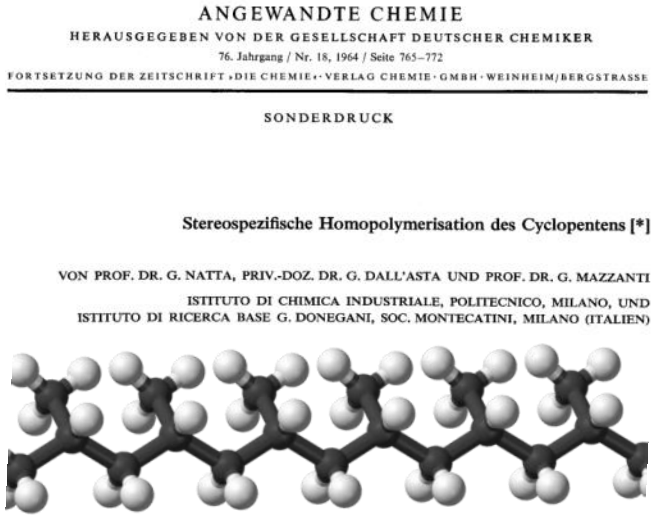
Idrogenazione bitumi ANIC (1935)

Eni Donegani Institute - a glorious tradition



- Mr. Giacomo Fauser, father of Fauser-Montecatini process for ammonia, a distinguished scientist and director of Montecatini and ANIC Novara. Has developed a number of petrochemical processes (ammonia, urea, methanol, acetylene, ethylene, methane reforming and bitumen hydrogenation). In 1971 there were 370 plants built in the world according to the Fauser-Montecatini technologies.

- Prof. Giulio Natta, inventor of polypropylene. Nobel Prize for Chemistry in 1963, has had a close collaboration with the Donegani Institute, as evidenced by numerous papers and patents. In the picture at the Milan Polytechnic, also appears Giorgio Mazzanti, Eni future president (1979-1980).



ANGEWANDTE CHEMIE
HERAUSGEGEBEN VON DER GESELLSCHAFT DEUTSCHER CHEMIKER
76. Jahrgang / Nr. 18, 1964 / Seite 765–772
FORTSETZUNG DER ZEITSCHRIFT „DIE CHEMIE" · VERLAG CHEMIE · GMBH · WEINHEIM/BERGSTRASSE

SONDERDRUCK

Stereospezifische Homopolymerisation des Cyclopentens [*]

VON PROF. DR. G. NATTA, PRIV.-DOZ. DR. G. DALL'ASTA UND PROF. DR. G. MAZZANTI
ISTITUTO DI CHIMICA INDUSTRIALE, POLITECNICO, MILANO, UND
ISTITUTO DI RICERCA BASE G. DONEGANI, SOC. MONTECATINI, MILANO (ITALIEN)

Eni Donegani Institute – History

History

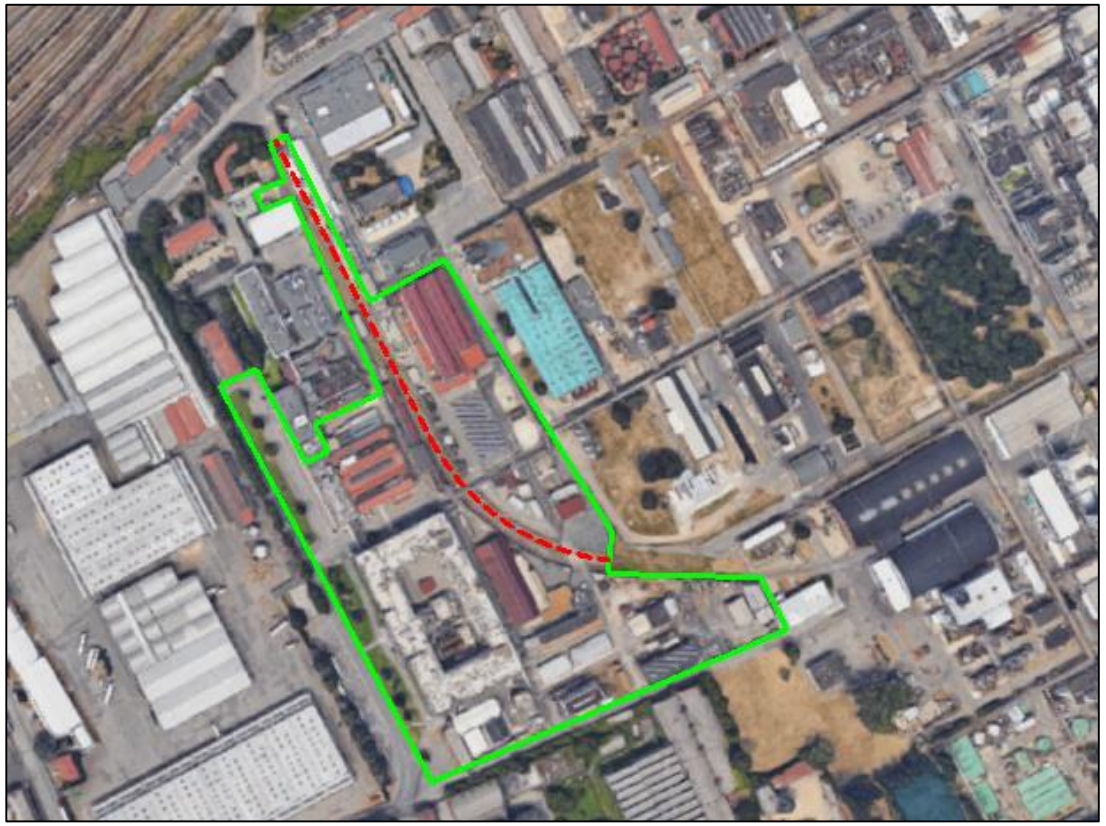
1936-1941
- Building of the Research Center: it becomes the most important R&D site of Montecatini

1942-1979
- Transition to Montecatini Edison group, then Montedison
- 1979 becomes an autonomous legal entity as Istituto Guido Donegani

1980-2001
- 1989 transition to EniMont, then EniChem S.p.A.
- 1993 Eni incorporates Guido Donegani company

2002-2006
- 2002 the Research Center is conferred to Polimeri Europa (Eni group)
- 2005 sale of the R&D business unit to EniTecnologie S.p.A.
- 2006 becomes part of R&D Department of Eni R&M Division

2006-today
- 2007 passes to Eni R&D Corporate (mission focused on Renewables & Environment)
- 2014 R&D Department is included into Developmet Operations & Technology Business Area

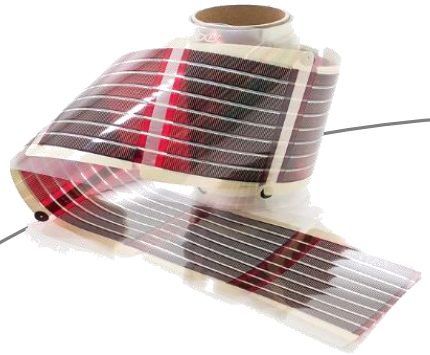


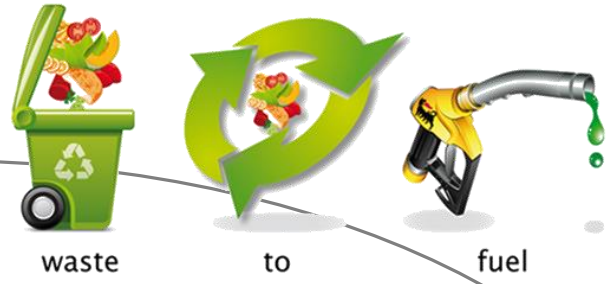
Eni Donegani Institute: Aerial photography of the area (Source: Google Maps)

Renewable energy, our technological portfolio

***Solar Energy* - Polymeric and "paper like" cells**

Low cost organic PV on flexible substrate for portable devices





Waste to Fuel

Second and third generation biofuels from organic fraction of urban solid waste

Renewable Energy

Energy storage

Flow batteries applications

***Solar Energy* - PV windows**

Luminescent Solar Concentrators (LSC), for residential building integration

***Solar Energy* – CSP**

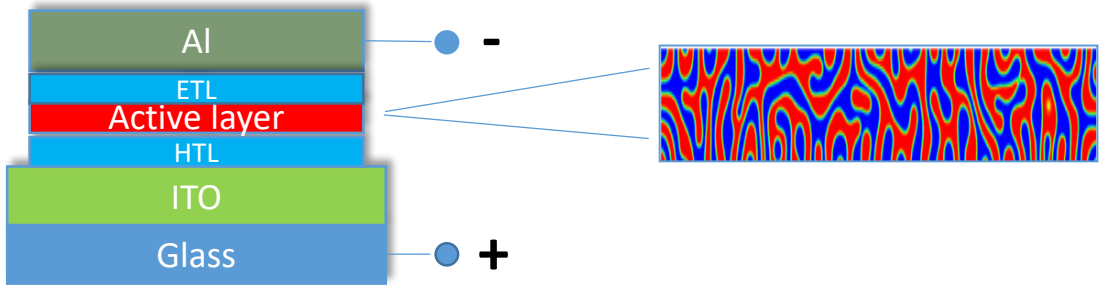
A new, proprietary, cost-effective technology for solar energy conversion

Utility-scale renewables and hybrid solutions

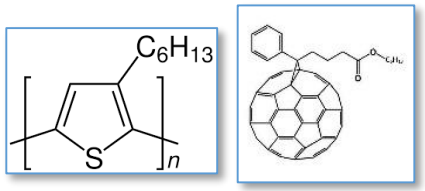
Hybrid systems among different renewables sources and gas plants

Organic Solar Cells (OPV)

Organic solar cells use polymers and other organic components as photoactive materials instead of silicon as for conventional PV (Si-PV). They can be printed in any shape on a flexible substrate with conventional ink-printing techniques (R2R). The technology can be applied on a light, flexible support, with a 90% weight reduction compared to conventional Si-PV, making it easily transportable and deployable.



Device Architecture of a BHJ solar cell



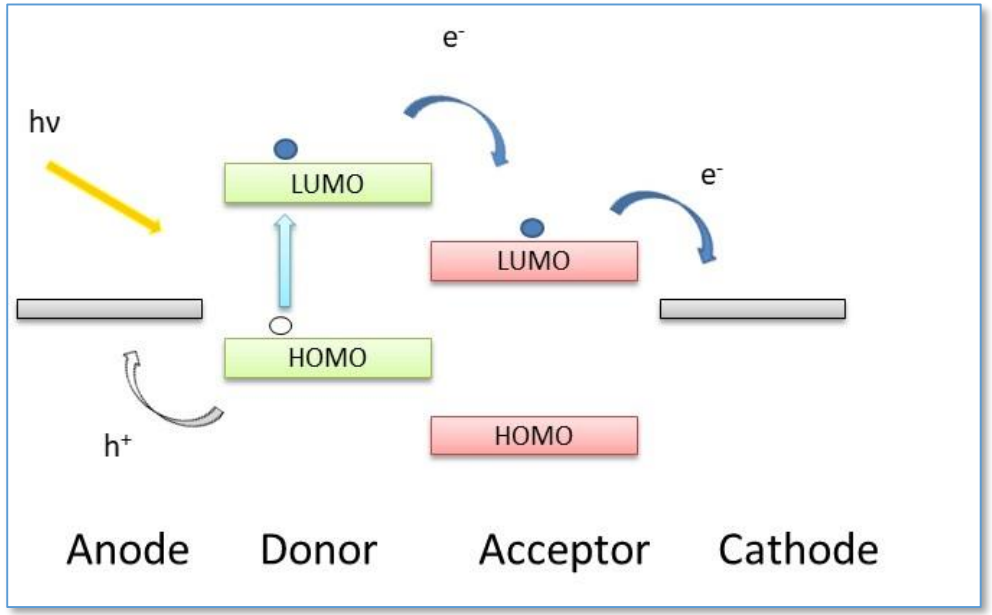
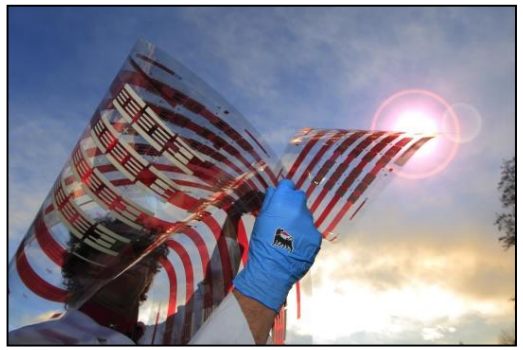
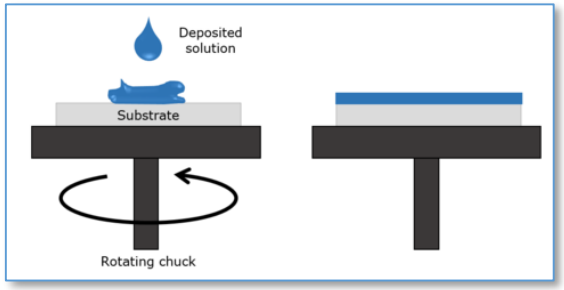
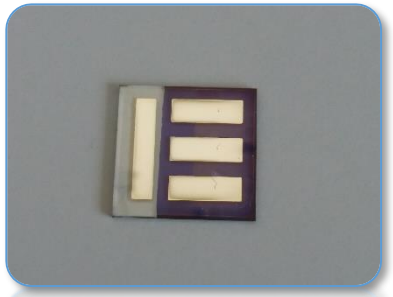


Photo-conversion process and energy level diagram in BHJ solar cell



Organic Solar Cell preparation



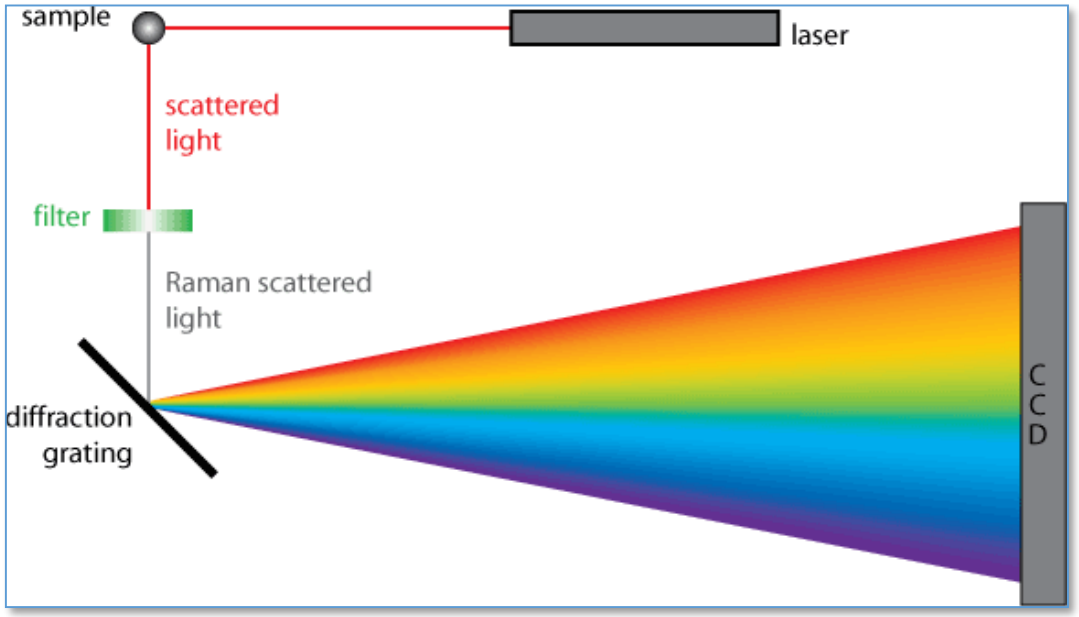


Spin-coating deposition

Ink-printing technique (R2R)

Raman Spectroscopy

Raman Spectroscopy is a non-destructive chemical analysis technique which provides detailed information about chemical structure, crystallinity and molecular interactions. It is based upon the interaction of light with the molecules within a material.



Schematic diagram of a Raman spectrometer

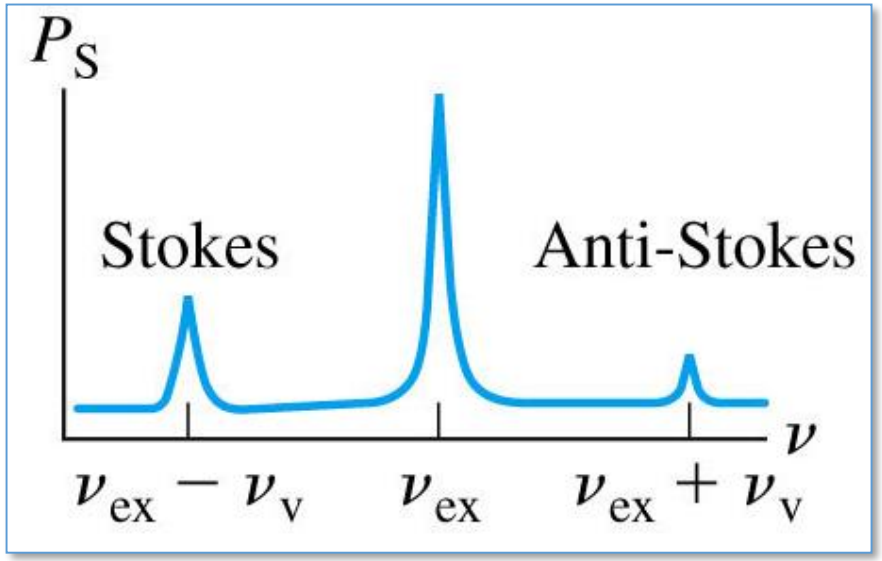
The Raman Effect

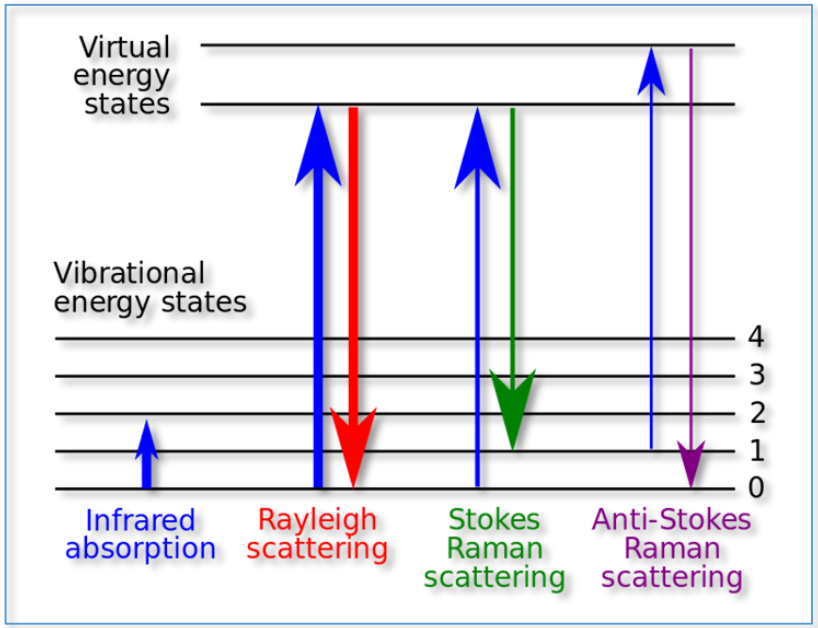
When light is scattered from a molecule most photons are elastically scattered. The scattered photons have the same energy (frequency) and, therefore, wavelength, as the incident photons. However, a small fraction of light (approximately 1 in 10^7photons) is scattered at optical frequencies different from the frequency of the incident photons (Raman Effect).

Elastic Scattering (Rayleigh scattering, same energy)

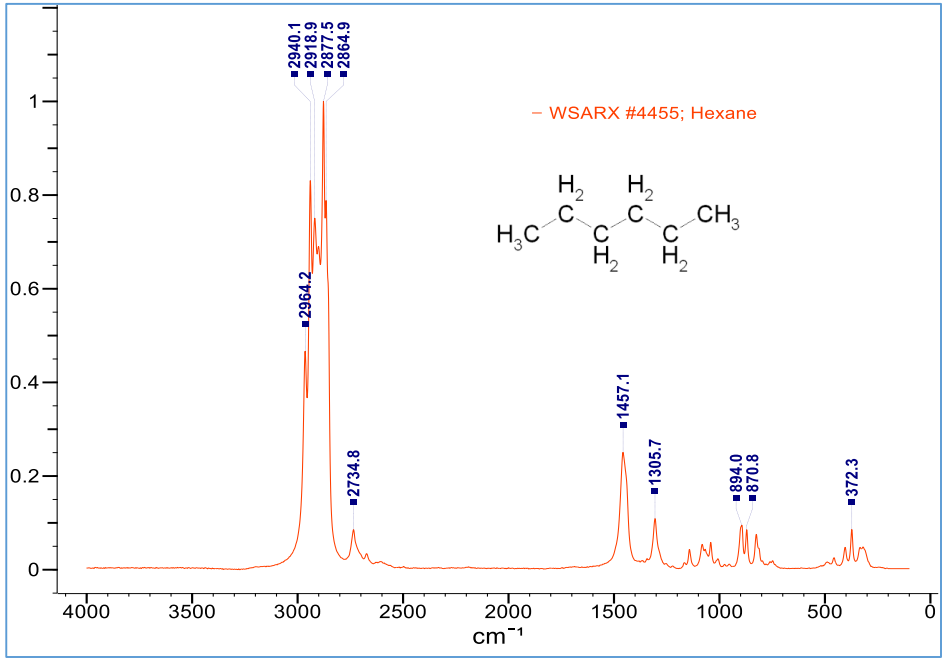
Inelastic Scattering (Stokes Raman scattering, lower energy)

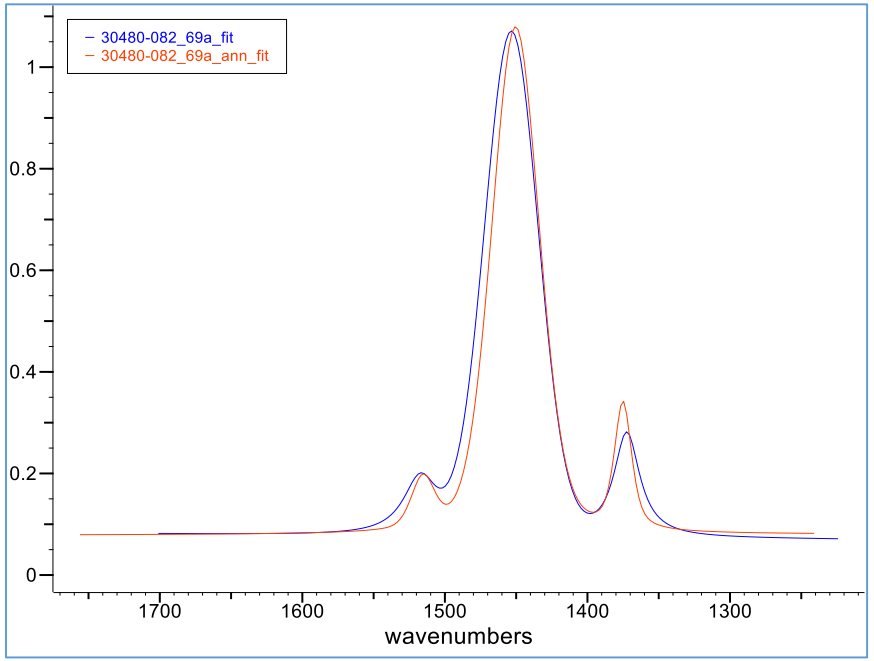
Inelastic Scattering (Anti-Stokes Raman scattering, higher energy)





What information does Raman spectroscopy provide ?





Chemical functional groups / compound identification

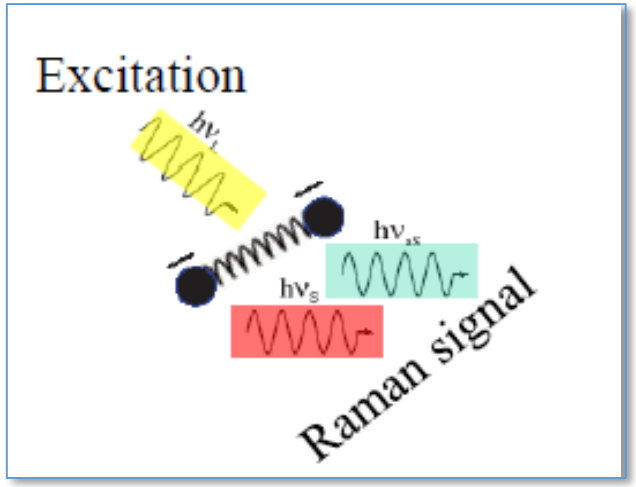
Hexane Raman Spectrum

Crystallinity analysis of materials

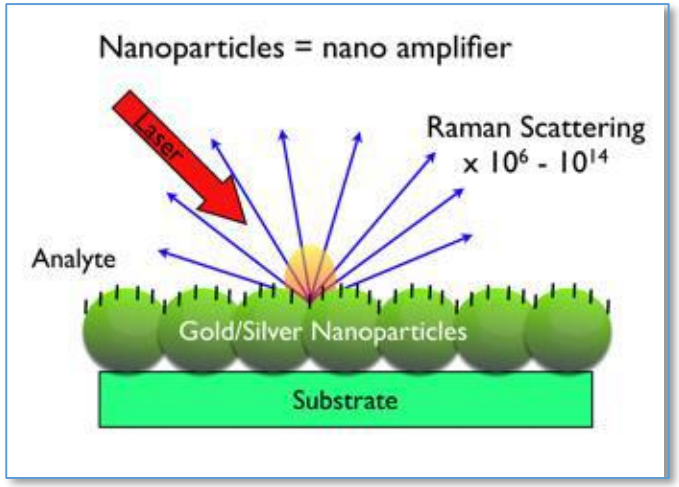
P3HT stretching vibration of the C=C bound at 1445 cm^{-1}

Surface Enhanced Raman Scattering (SERS)

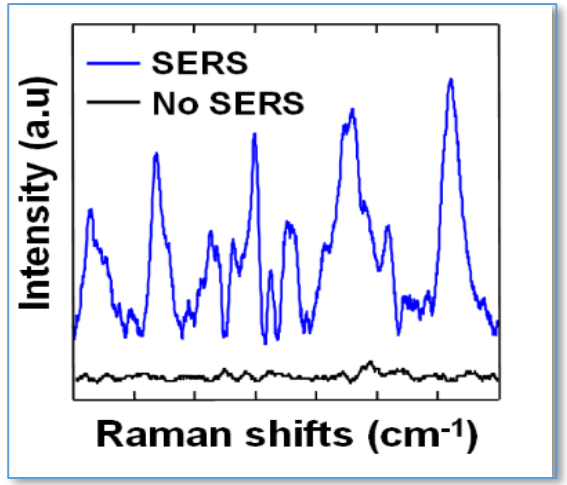
SERS: The enhancement factor can be as much as 10^{10} to 10^{11}



Raman Effect



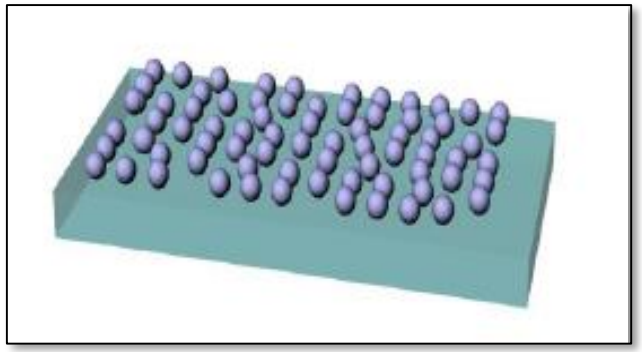
SERS Effect

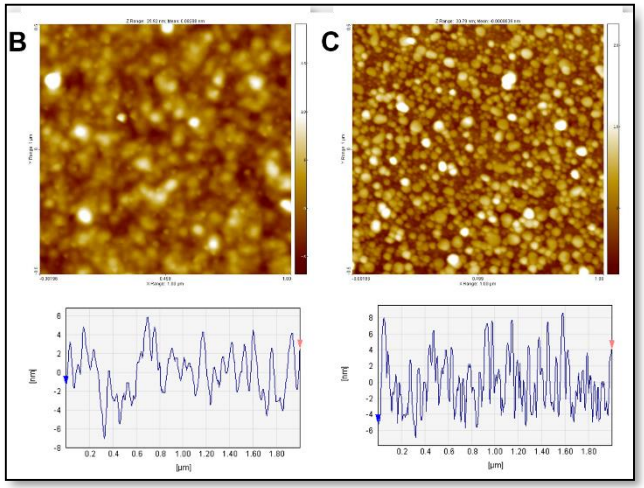


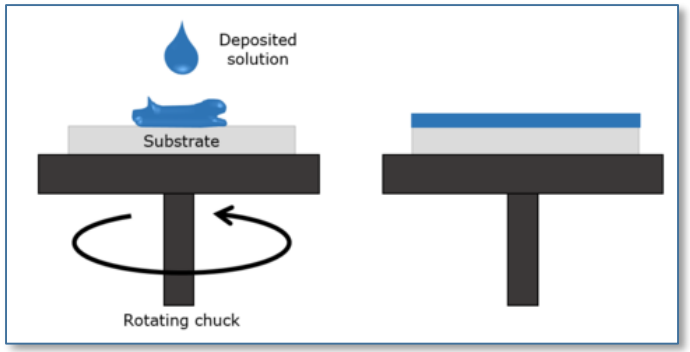
Comparison of SERS and normal Raman spectra

Activities description : samples preparation

University of Pavia / Eni Research Center - Novara







Fabrication of SERS substrates
University of Pavia

Morphological analysis of substrates
University of Pavia
Eni Research Center - Novara

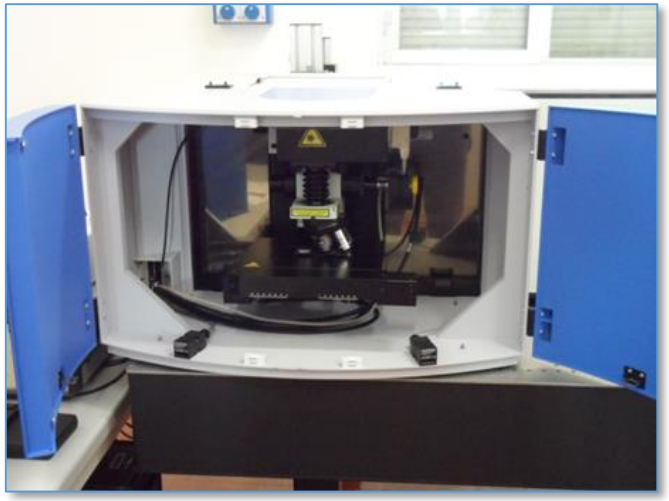
OPV Film deposition
Eni Research Center - Novara

Activities description: OPV characterization
Eni Research Center - Novara

Raman analysis of OPV films

Raman imaging to highlight possible material segregation (D/A)

PEDOT:PSS + nanoparticles [1] (Improved efficiency of organic solar cells)



Raman Spectrometer

1: Improved efficiency of organic solar cells using Au NPs incorporated into PEDOT:PSS buffer layer
AIP Advances 7, 085302 (2017)

Thesis proposal

Aim of the thesis: Organic solar cell characterization with SERS Spectroscopy

Activities:

1) Fabrication and characterization of SERS substrates.
2) Analysis of the active layer of Organic Solar Cells with SERS Spectroscopy

Venue: University of Pavia / Eni Research Center - Novara