

1.1 Address of public website

www.hysens.eu

The HYSENS website was one of the key tools used to disseminate details of the project, its overall technological aims and to disseminate progress of the project to the wider scientific community. The website includes details of publications, presentations (oral and poster), exhibitions.

Some snapshots of the website are highlighted below:

The screenshot shows the homepage of the HYSENS website. At the top, there is a navigation menu with links for Home, Overview, Market, Team, News, Partnerships & Collaborations, and Contact Us. Below the menu is a header banner featuring the HYSENS logo, the text "The Hysens Project", and logos for the European Commission's Framework Programme 7 and the European Union. The main content area is divided into two columns. The left column, titled "Latest News", contains a list of links: Article Image, Presentations, Education and Training, Contact Us, and Partnerships & Collaborations. Below this list is a small image of a biochip and a text box with article citation information. The right column features a heading "HYSENS is an acronym for:" followed by a quote: "Hybrid molecule nanocrystal assemblies for photonic and electronic SENSing applications". Below the quote is a paragraph describing the consortium, its funding (€3 million from FP7), and its goals. It mentions the synthesis of novel sensors for detecting various ions and anions in water. A second paragraph discusses the potential impact of smart hybrid nano-materials on the biosensors industry. At the bottom of the right column, there are two video player thumbnails. The first is titled "HYSENS Biochip" and the second is "HYSENS Biochip with Nanowire detection". Both video players show a play button and a progress bar.

Home Overview Market Team News Partnerships & Collaborations Contact Us

HYSENS The Hysens Project SEVENTH FRAMEWORK PROGRAMME

Latest News

- Article Image
- Presentations
- Education and Training
- Contact Us
- Partnerships & Collaborations

HYSENS is an acronym for:

"Hybrid molecule nanocrystal assemblies for photonic and electronic SENSing applications".

The **HYSENS** consortium is a world class interdisciplinary research and industrial team comprising of five universities, one research institute and three industry partners. The HYSSENS consortium has been granted €3 million from the **European Commission's Framework Programme 7 (FP7)** for a 3 year grant period from 1st April 2011 to 31st March 2014.

During this 3 year period, the main goal of the HYSSENS consortium is to assemble four novel classes of hybrid nanostructures using inorganic nanocrystals and organic functional molecules. These nanocrystals will be used to synthesize **novel sensors** for the detection of Group I, II, transition metal cations (Na⁺, Ca²⁺, Cu²⁺) and anions (F⁻, NO₃⁻, PO₄³⁻) in water and artificial serum matrices thereby targeting applications in the **clinical diagnostics industry** and the **water industry**.

Smart hybrid nano-materials with higher knowledge-content, tailored properties and predictable performance can have a potential enormous impact in the biosensors industry in a number of applications from **point-of-care**, **home diagnostics**, **research laboratory** and **environmental applications** where the market for such sensors was \$3,217.7M, \$1,290.1M, \$755.5M and \$830.8M in 2009 and is expected to grow to \$6,469.8M, \$2,929M, \$1,539.1M and \$2,065.1M, respectively by 2016.

Download **HYSENS Brochure** here for an overview of the project.

For an overview of how the technology works, please see the animation below, also hosted on Cellix's YouTube channel:

HYSENS Biochip **HYSENS Biochip with Nanowire detection**

Article citation: J. Mater. Chem. C, 2014, DOI: 10.1039/C3TC2499E
Title: Au Nanorod Plasmonic Superstructures Obtained by a Combined Droplet Evaporation and Stamping Method
Authors: Carola Schoof, Alfonso Martin, Micheál Burke, Daniel Jones, Andrea Pescaglini, Alan O'Riordan, Aidan J. Quinn and Daniela Iacopino*

Work Packages

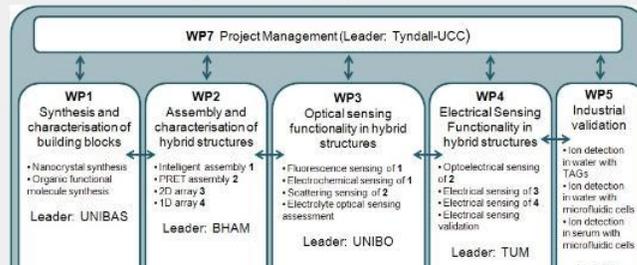
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The proposed innovation in HYSSENS relies on the use of hybrid inorganic-organic component materials leading to the development of sensors with enhanced selectivity and sensitivity. Inorganic nanocrystals and organic functional molecules will be used for the assembly of **four novel classes of hybrid nanostructures**:

- Intelligent assembly (1):** semiconductor nanocrystal - organic functional molecules for demonstration of optical "intelligent chemosensing" (**objective 1**) targeting ng/L concentration detection of Group I and II ions and anions (including Na⁺, Ca²⁺, PO₄³⁻, F⁻). Industrial validation of intelligent assembly 1 into polymer-patterned tag surfaces and microfluidic cells.
- PRET hybrid assembly (2):** metal nanocrystal - organic functional molecules for demonstration of optical sensing based on plasmon resonance energy transfer (PRET) mechanisms (**objective 2**) targeting ng/L concentration detection of transition metal including Hg²⁺ and Cu²⁺. Industrial validation of PRET assembly 2 into polymer microfluidic cells.
- 2D hybrid arrays (3):** metal nanocrystal - organic functional molecules for demonstration of large area sensing (**objective 3**) targeting electrical "intelligent chemosensing" of Group I and II cations and anions (including Na⁺, Ca²⁺, PO₄³⁻, F⁻) with ng/L detection limits.
- 1D hybrid arrays (4):** metallic semiconductor nanocrystal - organic functional molecules interfaced on 1D Si FETs arrays for electrical readout based sensing (**objective 4**) targeting electrical "intelligent chemosensing" of Group I and II cations and anions (including Na⁺, Ca²⁺, PO₄³⁻, F⁻) with ng/L detection limits. Industrial validation of 1D hybrid assembly into polymer microfluidic cells.

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The HYSSENS project involves a strong team consisting of 9 partners: 6 from academia and 3 from industry:



Tyndall National Institute, University College Cork (Ireland)

Tyndall National Institute at University College Cork (UCC) is the project co-ordinator of the HYSSENS project. The Tyndall National Institute is a premier ICT research institute affiliated to UCC with a critical mass of over 300 researchers with core competencies in micro/nanoelectronics, photonics, Microsystems and computational modeling. The Nanotechnology Group at TNI-UCC focuses on mid- to long-term research in development of nanoscale materials, structures and devices to enable development of future emerging electronics, photonics and biotech technologies.

Expertise leveraged for HYSSENS project: Synthesis of nanocrystal materials and optical characterization of nanostructures.

Contacts: Daniela Iacopino and Aidan Quinn

Website: <http://www.tyndall.ie/users/danielaiaopino>



University of Basel (Switzerland)

Department of Chemistry and Department of Physics

The University of Basel has many years of experience in the design of molecular species with defined electronic or photonic properties. These interests have recently evolved to include novel long-lived LECs and the design and synthesis of new nanoparticulate materials for incorporation into photovoltaic and other systems.

Expertise of Department of Chemistry leveraged for HYSSENS project: State-of-the-art synthesis and characterization of inorganic-organic hybrids and components; supramolecular chemistry and molecular electronics.

Expertise of Department of Physics leveraged for HYSSENS project: Electrical characterization of nanocrystal assembly, including electrochemical gating; also nanoelectronics and molecular electronics.

Contacts: Prof. Edwin Constable (Dept. of Chemistry); Prof. Christian Schonenberger and Dr. Michel Calame (Dept. of Physics).

Websites:

<http://www.chemie.unibas.ch/~constable/>

<http://www.physik.unibas.ch/dept/pages/de/personnel/schonenberger.htm>

News

[HYSENS Brochure](#)

[Publications](#)

[Presentations](#)

[Education and Training](#)

[Publishable Summary](#), 1st April 2011 to 30th September 2012

Category: News

The website also includes tools for exploitation including:

- **HYSENS Brochures:** Three brochures were designed during the project. The first brochure was designed as a short overview of the HYSSENS project.

www.hysens.eu

THE HYSSENS PROJECT

HYSENS is an acronym for:
"Hybrid molecule nanocrystal assemblies for photonic and electronic SENSing applications"

HYSENS Goal
Exploit organic functional molecules and inorganic nanocrystals as building blocks for the assembly of novel smart materials for detection of Group I, II, transition metal cations and anions in water and artificial serum matrices.

Why are we doing this?
The increasing shortage of the water supply has led to the implementation of recycling plants for both potable water and technological applications, increasing the demand for low cost and rapid contaminant detection technologies. This presents a significant problem for existing and future industries, requiring the incorporation of both expensive ultrapure water and water analysis systems. For example, state-of-the-art wafer fabrication facilities consume 100-300 m³ of ultrapure water per hour.

Industry Needs:

- Semiconductor Fabrication: In daily routine, inorganic cations on a silicon wafer surface and in ultrapure water are detected at concentrations down to (and below) the ng/L range using inductively coupled plasma mass spectrometry (ICP-MS). However this technique is at present prohibitively expensive to implement.
=> **HYSENS solution is more cost-effective.**
- Healthcare: In clinical diagnostics, there is an increasing demand for the development of innovative low cost electrolyte analysis technologies that could be applied for example in emergency rooms to obtain a fast indication for the diagnosis of specific diseases. Existing techniques meet concentration specifications required. However, more accurate, selective and sensitive methods would revolutionise the field of diagnostics for early detection and management of renal, endocrine, acid-base, water balance disorders, and many other conditions.
=> **HYSENS solution is more sensitive.**

HYSENS Objectives to achieve our Goal:
HYSENS relies on the use of hybrid inorganic-organic component materials leading to the development of sensors with enhanced selectivity and sensitivity. Inorganic nanocrystals and organic functional molecules will be used for the assembly of four novel classes of hybrid nanostructures:

- 1. Intelligent assembly (1):** semiconductor nanocrystal - organic functional molecules for demonstration of optical "intelligent chemosensing" (**objective 1**) targeting ng/L concentration detection of Group I and II ions and anions (including Na⁺, Ca²⁺, PO₄³⁻, F⁻). Industrial validation of intelligent assembly 1 into polymer-patterned tag surfaces and microfluidic cells.
- 2. PRET hybrid assembly (2):** metal nanocrystal - organic functional molecules for demonstration of optical sensing based on plasmon resonance energy transfer (PRET) mechanisms (**objective 2**) targeting ng/L concentration detection of transition metal including Hg²⁺ and Cu²⁺. Industrial validation of PRET assembly 2 into polymer microfluidic cells.
- 3. 2D hybrid arrays (3):** metal nanocrystal - organic functional molecules for demonstration of large area sensing (**objective 3**) targeting electrical "intelligent chemosensing" of Group I and II cations and anions (including Na⁺, Ca²⁺, PO₄³⁻, F⁻) with ng/L detection limits.
- 4. 1D hybrid arrays (4):** metallic semiconductor nanocrystal - organic functional molecules interfaced on 1D Si FETs arrays for electrical readout based sensing (**objective 4**) targeting electrical "intelligent chemosensing" of Group I and II cations and anions (including Na⁺, Ca²⁺, PO₄³⁻, F⁻) with ng/L detection limits. Industrial validation of 1D hybrid assembly into polymer microfluidic cells.

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THE HYSENS PROJECT



Achievements to date:

- The synthesis of a library of metal and semiconductor nanocrystals is complete.
- The original list of seventeen selected hybrid (assembly) structures has been reduced to eleven (kick off meeting) in order to focus the energies and resources of the consortium into the assembly and testing of hybrid structures.
- At the first annual scientific meeting, a funnelling phase was implemented, whereby five organic ligands were selected for further studies during the second part of the project. Therefore, synthesis of organic ligands is completed, molecules have been distributed to partners and routes for scaling up synthesis at gram scale are being developed by partner UNIBAS Chem.
- Assembly of the following prototypes are complete and opto-electrical characterisation of the assemblies are underway:
 1. Intelligent assembly 1
 2. PRET assembly 2
 3. 2D hybrid arrays 3
 4. Hybrid arrays 4
- In particular, intelligent assembly 1 composed of C1 and CdSe quantum dots (QDs) has been synthesised and its luminescent and electrical behaviour response to Na⁺ ions is currently under investigation.
- The fabrication of electrochemical cells is complete. These cells are now being tested for use with quantum dot (QDs) materials.

- Si nanowire FETs have been fabricated and will be tested with the Hysens hybrid structures.
- Preliminary investigation of the deposition of metal nanoparticles and QDs on patterned tags has been achieved with fluorescent tags fabricated by partner SCRIBA.
- A first generation of microfluidic cells has been fabricated by Mildendo and distributed to partners. Methodologies for the incorporation of metal nanoparticles in microfluidic cells have been developed by Tyndall-UCC in collaboration with Cellix.
- A mini-business plan has been written identifying potential partners for commercialization of the technology.
- Dissemination and exploitation of results.

Results & Expected Impact:

The HYSENS project is on track to achieve all of its ambitious objectives and deliver four optimised hybrid structures displaying enhanced selectivity and sensitivity of detection towards selected metal anions and cations, in water and serum matrices. A successful Hysens project will provide a number of clear benefits over the current method of detection offering:

- Higher performance detection,
- Low cost and
- Ease of use

The outputs of the HYSENS project are thus very attractive commercially for both the water and point-of-care markets.

HYSENS:
"Hybrid molecule nanocrystal assemblies for photonic and electronic SENSing applications"

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Project Team:
Tyndall National Institute, Ireland
University of Basel, Switzerland
University of Bologna, Italy
University of Birmingham, UK
University of Valencia, Spain
Technical University of Munich, Germany
Scriba Nanotechnologie s.r.l., Italy
Cellix Limited, Ireland
Mildendo GmbH, Germany

Project Timeline: 1st April 2011 – 31st March 2014

Project Cost: €3,979,357

EC Funding: €3,000,000

Grant Instrument: NMP3-SL: Small scale collaborative project

Grant Agreement No.: 263091

Keywords: Hybrid molecule nanocrystals assemblies; photonic sensing; electronic sensing

Brochure 1: HYSENS Overview

Two further brochures were developed towards the end of the project; one for dissemination to the scientific community publicising results of the HYSENS project and a second one for the general public giving an overview of the importance of the results achieved to the wider community.

HYSENS
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THE HYSENS PROJECT

7
EUROPEAN UNION

Tyrndal
UNIVERSITY OF BIRMINGHAM
UNIVERSITY OF VALENCIA
MIRA Security Centre
CEITEC
MIRA

HYBRID MOLECULE NANOCRYSTAL ASSEMBLIES FOR PHOTONIC AND ELECTRONIC SENSING APPLICATIONS

The main objective of the HYSENS project is to exploit organic functional molecules and inorganic nanocrystals as building blocks for the assembly of novel hybrid smart materials for detection of Group I, II, transition metal cations and anions in water and artificial serum matrices. A series of hybrid materials were synthesised and the potential for ion sensing with low sensitivity and high selectivity in water has been demonstrated. The project has met most of the targeted limits of detection, thus showing the potential of these materials to provide alternatives to currently used cumbersome analytical tools. Furthermore, the integration of the sensor units into model structures and subsequent demonstration of optical and electrical read outs emphasises the exploitation potential of the HYSENS platform and its potential benefit for EU citizens and industry.

PROJECT HIGHLIGHTS

1. A series of building blocks constituted by inorganic nanocrystals and organic ligands were designed and successfully prepared. Organic ligands were engineered to bear anchoring groups for inorganic nanocrystals and functional groups for the selective complexation of group I and II cations, heavy cations and anions. The inorganic nanocrystals were engineered to transduce ion sensing promoted by the organic ligand moiety into an optical or electrical read-out.
2. Four classes of hybrid structures constituted by synthesized building blocks were assembled and characterized.
3. Luminescent sensors were developed, showing high affinity for heavy metal ions such as Pb^{2+} and Cu^{2+} , with limits of detection (LODs) below 10 and 1 $\mu g/L$, respectively. Sensors based on the modulation of scattering intensity of inorganic nanoparticles were also developed with demonstrated sensitivity for Hg^{2+} < 200 $\mu g/L$.
4. Ion-selective organic electrochemical transducers (IS-OECTs) were fabricated with electrochemical detection of K^+ in the μM range demonstrated.
5. Si nanowire FETs were fabricated and chemically modified with hybrid molecules. Successful electrical detection of Na^+ with 100 $\mu g/L$ LOD was demonstrated. Multiplex cation/anion detection (Na^+/F^-) was achieved with Si nanowire FETs integrated into microfluidic flow cells.
6. Fabrication of optical sensor based on a miniaturized data matrix code En-TAG™ with built in optical reader for fluorescence and scattering read out. Fluorescence detection of Na^+ and initial scattering detection of Cu^{2+} with $\mu g/L$ limits of detection were achieved.
7. Low leakage flow cells were fabricated and optimised for fluorescence and scattering read out. Hg^{2+} and F^- detection at ng/L level was achieved with incorporated hybrid molecules.

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HYSENS
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THE HYSENS PROJECT

7
EUROPEAN UNION

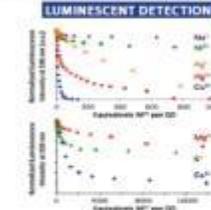
CONCEPT



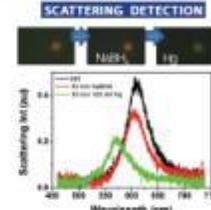
MOLECULES **NANOCRYSTALS** **ION DETECTION**

IMPLEMENTATION

LUMINESCENT DETECTION



SCATTERING DETECTION



INDUSTRIAL VALIDATION

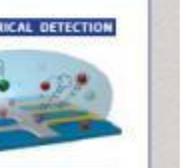
ELECTROCHEMICAL DETECTION



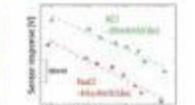
OPTICAL DETECTION ON TAGS



ELECTRICAL DETECTION







Brochure 2: HYSENS Scientific Results

HYSENS www.hysens.eu
THE HYSENS PROJECT

Tyndall ITC UNIVERSITY OF BIRMINGHAM UNIVERSITAT DE VALÈNCIA IVC - IONIC VIBRATIONAL CATALYSIS CELIX MICROFAB

HYBRID MOLECULE NANOCRYSTAL ASSEMBLIES FOR PHOTONIC AND ELECTRONIC SENSING APPLICATIONS

The HYSENS project develops hybrid smart materials for the detection of ions in water and biological fluids. New materials capable of detecting biologically or environmentally important ions at low sensitivity and high selectivity have been developed. The use of intelligent nanomaterials provides cheap and portable alternatives to currently used cumbersome analytical tools.

For example, ultrapure water is an essential reagent for the manufacture of semiconductor, pharmaceutical and power plant industries. Existing and future industries are required to detect contaminant levels down to nanogram/L concentration limits. These limits can today only be met with the incorporation of water analysis systems prohibitively expensive to implement.

On the other hand in the clinical diagnostic area there is an increasing demand for development of innovative low cost analysis technologies that could be applied for example in emergency rooms in analysis of body fluids to obtain fast indication for the diagnosis of specific diseases. The unique consortium of academic and industry physicists, chemists and technologists has developed novel hybrid materials. Such materials have been incorporated into devices and sensor modalities of highly sensitivity and selectivity have been fabricated.

PROJECT HIGHLIGHTS

- Four classes of hybrid structures constituted by synthesised building blocks were assembled and characterised.
- Light-based sensors have been developed for the detection of environmentally damaging and toxic metals such as mercury, copper and lead in water.
- Electronic sensors have been assembled for the detection of sodium and potassium in water and blood serum.
- Electrochemical sensors for detection of potassium in water were developed.
- Devices based on miniaturized optical sensors for optical read out have been developed for proof-of-concept detection of sodium and copper.
- The technologies have been incorporated into microfluidic devices.
- New materials and methods have been developed of wide potential in nanotechnology and sensor applications.

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HYSENS www.hysens.eu
THE HYSENS PROJECT

Tyndall ITC UNIVERSITY OF BIRMINGHAM UNIVERSITAT DE VALÈNCIA IVC - IONIC VIBRATIONAL CATALYSIS CELIX MICROFAB

ION DETECTION (SERUM) **ION DETECTION (WATER)**

MOLECULES **NANOCRYSTALS**

MERCURY, CALCIUM, COPPER DETECTION

MERCURY DETECTION

POTASSIUM DETECTION

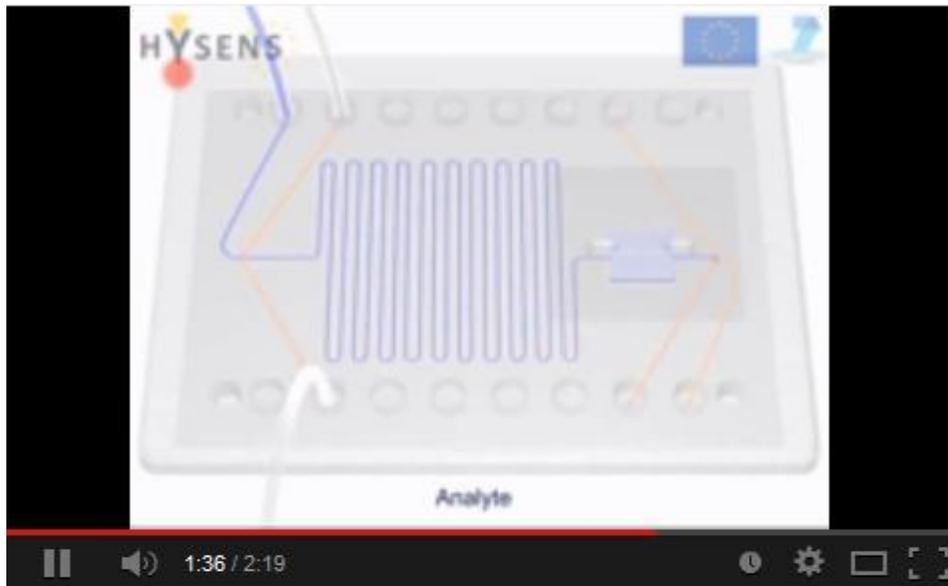
POTASSIUM/SODIUM DETECTION

CONTAINS: CALCIUM, SODIUM, POTASSIUM

Brochure 3: HYSENS General Flyer for wider public dissemination

All brochures are downloadable as pdfs from the website and can be used by partners to explain the project to potential interested partners (industry, academia, press etc.).

- **HYSENS animation:** This is short animation which briefly explains how an assembly, embedded on-chip, is used as a sensor for the detection of analytes. This is hosted on Cellix's YouTube and linked directly to the HYSENS website homepage. A second animation was produced from July – September 2013 to explain the operation of the nanowire embedded sensor from University of Basel. As with the first animation, this is also hosted on Cellix's YouTube channel and linked directly to the HYSENS website homepage. Both animations have been shown by Cellix at two exhibitions; Lab-on-a-chip World Congress, San Diego, September 2013 and Lab-on-a-chip European Congress, Berlin, March 2014.



HYSENS Biochip



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226 views

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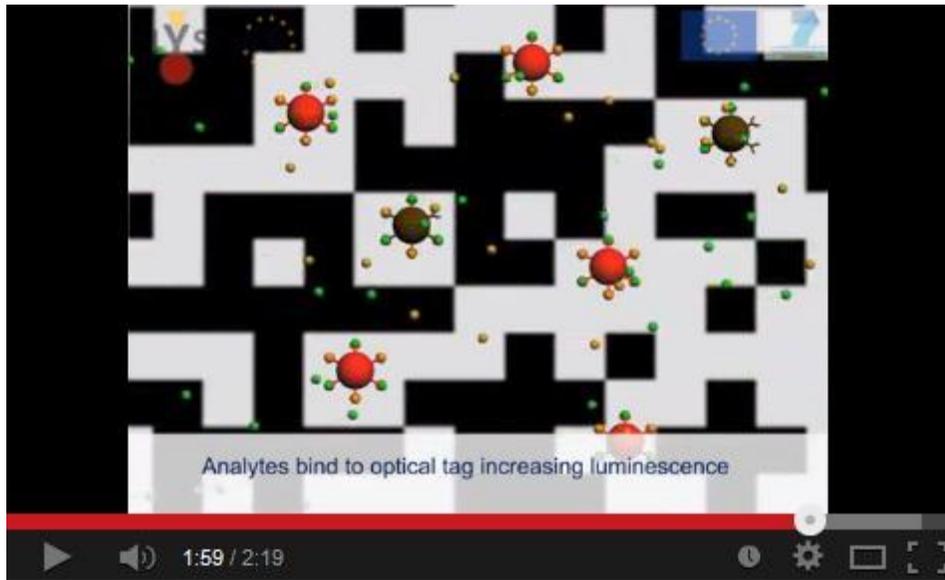


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During this 3 year period, the main goal of the HYSENS consortium

Animation explaining HYSENS sensor embedded in microfluidic biochip



Close-up of video animation explaining the embedded sensor on-chip.