



## Call for applications for the International PhD in Science at Università Cattolica del Sacro Cuore – XXXVIII Cycle – Brescia campus

### Art. 1 Opening

This Call indicates the Coordinator, the partner universities, the duration of the course, the number of positions available and the number of scholarships granted by the partner Universities of the International PhD in Science.

Any further information concerning the competition will be published on the site <https://dottorati.unicatt.it/concorsi-milano>

Coordinator: Professor Prashant V. KAMAT - University of Notre Dame, Indiana (United States of America).

Duration: 4 years.

Positions:

Funded positions: 3

Additional funded positions: see art. 2 of the present call for application.

Information: <https://scuoledidottorato.unicatt.it/phdschools/science-home?rdeLocateAttr=en>

Details of the positions (see also <https://scuoledidottorato.unicatt.it/phdschools/science-10695.html>):

**No. 1 scholarship (joint research project between Università Cattolica del Sacro Cuore and KU Leuven, Belgium) on “Time-resolved optical microscopy techniques to characterize 2D transition metal dichalcogenides”.**

Background and motivation

2D transition metal dichalcogenides (TMDs) hold great potential for application in different fields, in particular in nanoelectronics and photonics. In nanoelectronics, large energy dissipation due to heating in chips is unsustainable in terms of both costs and performance drop and 2D TMDs hold great potential to alleviate these problems. In photonics, the integration of 2D TMDs is predicted to enhance the energy harvesting. Towards such applications, it is crucial to develop a controlled, engineered, synthesis at large scale of such materials with high uniformity and to investigate their electronic/optical/thermal dynamics. Among the TMDs, MoS<sub>2</sub>, MoTe<sub>2</sub>, WS<sub>2</sub> and WTe<sub>2</sub> and are the most attractive materials to be investigated.

The aim of this project is to synthesize and characterize the 2D TMDs materials and develop ultrafast temporally and spectrally resolved high resolution optical microscopy



methods to investigate the electronic and thermo-mechanical aspects of 2D TMDs deposited on a bulk substrate.

The main aspects of the project are:

1. Synthesis of the 2D TMDs and characterization with spectroscopic ellipsometry.
2. Fast optical surface mapping in various environments (i.e. air and liquids) by microsphere assisted optical microscopy to get sensitivity to the few atomic layers constituting the surface termination;
3. Investigation of hot spots and dielectric spacers;
4. Use of neural networks and machine learning techniques to analyze experimental data.

#### Candidate Profile

- Diploma: Master's degree or comparable qualification in Physics, Materials Science, Materials Engineering, Electronic Engineering or adjacent fields. The title must be obtained before October 31<sup>st</sup>, 2022;
- A strong interest for multidisciplinary research is required;
- Previous experience in the growth of 2D transition metal dichalcogenides by chemical vapor deposition and their characterization using Raman spectroscopy, scanning electron microscopy and electrical methods (C-V, I-V, Internal photoemission) and/or in microscopy and/or ultrafast optics will be considered as an additional advantage;
- Candidates should have a solid background in optics and/or materials science;
- Good knowledge of the English language, both spoken and written, is essential;
- Strong commitment, ability to work in a team, and eagerness for international mobility is desired.

#### Opportunities

- Participating to an international collaboration among Università Cattolica del Sacro Cuore, Institute of Microelectronics and Microsystems (IMM-CNR) and KU-Leuven (Belgium);
- Double degree opportunity.

#### Supervisors

- Prof. Gabriele Ferrini, UCSC [gabriele.ferrini@unicatt.it](mailto:gabriele.ferrini@unicatt.it)
- Dr. Alessio Lamperti, IMM-CNR [alessio.lamperti@mdm.imm.cnr.it](mailto:alessio.lamperti@mdm.imm.cnr.it)
- Prof. Valeri Afanasiev, KU-Leuven [valeri.afanasiev@keuleuven.be](mailto:valeri.afanasiev@keuleuven.be)



## **No. 1 scholarship (joint research project between Università Cattolica del Sacro Cuore and KU Leuven, Belgium) on “Novel architectures for advanced sensing based on 2D materials platforms”.**

### Background and motivation

Among forefront applications of 2D materials such as graphene (GR) and transition metal dichalcogenides (TMDs) the detection of sub-ppm concentrations of small molecules on a background of strongly interfering gas mixtures is currently challenging physics, chemistry and device engineering and requires an in-depth knowledge of molecule-surface interactions at the nanoscale. These materials provide a unique opportunity to discover new sensing layers either through functionalization of single 2D layers or through a combination of 2D layers of different compounds to obtain novel heterostructures.

In this project, platforms based on properly functionalized 2D materials will be developed to produce arrays of miniaturized sensors for applications in the field of volatolomics, i.e. the profiling of VOCs emitted by living organisms, which is taking an increasing importance in various scientific areas such as medicine, as well as food and environmental sciences.

Bridging surface chemistry with device engineering, this project is aimed to develop ultra-sensitive arrays of sensing layers for the detection of biomarkers of lung pathologies in the exhaled breath. Layers characterization will involve photoemission and Raman spectroscopies, along with scanning probe spectro-microscopies. All materials will be functionalized at the nanoscale with selected molecules to make them more selective to specific target molecules. Data analysis with machine learning methods will be used to discriminate potential pathologies through pattern recognition in molecular fingerprint of breath samples.

### Candidate Profile

- Master's degree or comparable qualification in physics, chemistry, materials science or adjacent fields. The title must be obtained before October 31st, 2022;
- A strong interest for multidisciplinary research is required;
- Previous experience in either surface science, micro-spectroscopy, nanomaterials preparation and characterization;
- Good knowledge of the English language, both spoken and written, is essential;
- Strong commitment, ability to work in a team, and eagerness for international mobility is desired.

### Opportunities

- Experimental research participating to the international collaboration between Università Cattolica del Sacro Cuore, and KU Leuven with at least one year spent in both institutions;
- Double degree opportunity.

### Supervisors:

- Prof. Luigi Sangaletti UCSC, Italy, [luigi.sangaletti@unicatt.it](mailto:luigi.sangaletti@unicatt.it)
- Prof. Steven De Feyter, KU Leuven, Belgium, [steven.defeyter@kuleuven.be](mailto:steven.defeyter@kuleuven.be)



**No. 1 scholarship (joint research project cofounded between Università Cattolica del Sacro Cuore and KU Leuven, Belgium) on “Coherent control of electronic dynamics in layered quantum materials” funded by Università Cattolica del Sacro Cuore – MIUR PRIN 2020, prot. 2020JLZ52N\_003, CUP J55F21004280008, Light-matter interactions and the collective behavior of quantum 2D materials (Q-Lima)**

Background and motivation

Cooperative effects induced by light-matter interactions have been studied for decades. These studies have focused on atomic and molecular systems and have led to spectacular experimental findings in the realm of cavity quantum-electrodynamics (QED). In standard cavity-QED, direct interactions between matter constituents are often weak and can be neglected. In this case, collective effects are solely due to effective interactions, which emerge from the microscopic interactions between matter constituents and a common cavity mode. Recent experimental advances have made it possible to monolithically integrate graphene and other two-dimensional (2D) materials, such as transition metal dichalcogenides (TMDs) or 2D oxides, with optical microcavities, paving the way for fundamental studies of cavity QED at the nanometer scale with 2D materials as the active medium. Here, in stark contrast to ordinary cavity QED of atomic and molecular systems, direct interactions between medium excitations (electrons, holes, and excitons) in 2D materials are strong and can be further enhanced by stacking 2D materials in a van der Waals (vdW) heterostructure. The aim of this project is to investigate the main channels driving the electronic decoherence in layered quantum materials embedded in properly designed cavities and develop strategies and excitation protocols to preserve coherence and exploit coherent dynamics to enhance the physical properties of the material.

The PhD student will develop a coherent 2-dimensional electron spectroscopy (2DES) experiment to investigate the decoherence dynamics of optical and electronic excitations in nanostructured correlated materials. 2DES measures the third-order material coherent polarization by exploiting two coherent phase-locked pulses acting as a pump, and a third pulse acting as a probe, allowing for simultaneous resolution of excitation and detection frequency axes with fs temporal resolution. 2DES thus allows to investigate not only the population relaxation time, but directly the decoherence time of relevant modes. 2DES will be used to

probe the decoherence dynamics of light-induced exciton gases in 2D materials (TMDs and oxides). In particular, we will look for signatures of modification of the intrinsic decoherence dynamics driven by: i) coherent interactions within the exciton gas; ii) coupling of inter-layer excitonic modes in vdW heterostructures; iii) coupling to cavity modes. A crucial challenge is related to the sample dimensions, which command spatial resolution, mandatory to perform 2DES on micrometer-sized samples, possibly embedded in cavities. Much of the initial experimental efforts will focus on the implementation of a microscopy measurement scheme, to be coupled to state-of-the-art 2DES setups available at Università Cattolica del Sacro Cuore, providing few-micron spatial resolution while retaining the intrinsic temporal resolution (10-20 fs).

Candidate profile

- Master's degree or comparable qualification in Physics, Materials Science or adjacent fields. The title must be obtained before October 31st, 2022;



- A strong interest for multidisciplinary research is required;
- Previous experience in ultrafast science, solid state spectroscopies, 2D materials, cavity-embedded devices will be considered as an advantage;
- Good knowledge of the English language, both spoken and written, is essential;
- Strong commitment, ability to work in a team, and eagerness for international mobility is desired.

#### Opportunities

- The PhD will join the ultrafast dynamics group, led by Prof. Claudio Giannetti, and will have full access to the research facilities of the ILAMP research center, located in the new Mompiano Campus in Brescia;
- The researcher will take part to a joint experimental/theoretical effort to tackle the control of coherent dynamics in condensed matter by using different multidisciplinary platforms. The network includes Prof. J-P Locquet and M. Houssa (KU Leuven), Prof. Marco Polini (theory of collective phenomena in 2D materials, Università di Pisa), Prof. Massimo Capone (theory of correlated materials, SISSA Trieste);
- The PhD will spend at least 1 year (out of 4) at KU Leuven. At the end of the program the PhD student will be awarded a degree from both UCSC and KU Leuven (double-degree).

#### Contacts:

- Prof. Claudio Giannetti (UCSC) Italy, [claudio.giannetti@unicatt.it](mailto:claudio.giannetti@unicatt.it)
- Prof. J-P Locquet, KU Leuven, BE, [jeanpierre.locquet@kuleuven.be](mailto:jeanpierre.locquet@kuleuven.be)

### **Art. 2**

#### **Scholarships according to Ministerial Decrees 351/22 and 352/22**

Further funded positions, according to Ministerial Decrees 351/22 and 352/22, and financed/co-financed by the National Recovery and Resilience Plan (PNRR) (Programma Nazionale di Ripresa e Resilienza - PNRR), are also foreseen within the present Call, as specifically detailed in Attachment sub 1,

The availability of the mentioned scholarships covers the following areas:

- Ministerial Decree 351/22: scholarships finalized to the research development on digital and green transition; on PNRR's specific themes (digitalization, innovation, competitiveness, culture e tourism; green revolution and ecological transition; sustainable mobility; education and research; inclusion and cohesion; health), on Public Administration issues, on cultural heritage themes;
- Ministerial Decree 352/22: scholarships for innovative doctoral programmes, in collaboration with enterprises and organizations.

PhD candidates resulting holders of a scholarship according to Ministerial Decree 352/22, shall:

- Spend a study period within a firm or a research centre, from a minimum of 6 up to 18 months (this is not compulsory for candidates dealing with research positions on PNRR issues, according to Ministerial Decree 351/22, art. 7);



- Spend a study period abroad, from a minimum of 6 up to 18 months.

PhD candidates resulting holders of a scholarship according to Ministerial Decree 352/22, shall:

- Spend a study period within a firm, from a minimum of 6 up to 18 months;
- Spend a study period abroad, from a minimum of 6 up to 18 months.

### **Art. 3**

#### **Assessment procedure**

The comparative evaluation of candidates applying to the International PhD in Science aims to discern the candidate's aptitude for and interest in the scientific research proposed in the Research Program. The examination panel reserves the right to ask for an online interview.

### **Art. 4**

#### **Admission requirements**

Application for participation in the competition, with no restrictions with respect to age and nationality, is open to candidates holding a Master's degree, or an Italian university degree obtained under the education system prior to Italian Ministerial Decree no. 509 of November 3<sup>rd</sup>, 1999 or a second-level university qualification obtained abroad and deemed eligible.

Application for participation is also open to candidates due to obtain one of the above-mentioned qualification by October 31<sup>st</sup>, 2022. In this case, examination candidates shall provide the Examination Panel with a self-declaration form attesting graduation or a qualification from a foreign university. Failure to do so will be cause for invalidation of the application.

Italian, EU and non-EU candidates who obtained, or will obtain, a qualification abroad, by October 31<sup>st</sup>, 2022, for the sole purpose of admission to the PhD Programme shall request recognition of its eligibility in the PhD Programme application form. To this end, the application shall be accompanied with appropriate documentation to enable the Examination Panel to rule on the request for eligibility.

### **Art. 5**

#### **Application form**

Candidates who intend to participate to the competition must submit an application to the Rector of Università Cattolica del Sacro Cuore by **Tuesday, August 23<sup>rd</sup>, 2022**.

The application form is available at <https://progetti.unicatt.it/progetti-ateneo-bandi-e-concorsi-milano-piacenza-brescia#content> until 2 p.m. (CEST) of the expiration date of the present public announcement.

In the application form, to be filled in English and online only, candidates shall declare under their responsibility:

- the choice of at least one of the research projects offered by Università Cattolica del



- Sacro Cuore;
- personal information: surname, first name, fiscal code (for Italian nationals only), date and place of birth, citizenship, residence and domicile elected for the purposes of the competition;
  - for graduate students: qualification, date it was obtained and name of the conferring university;
  - foreign languages known besides English.

Candidates must complete their application with the following documents – upload format .pdf or .jpg:

- a detailed *curriculum vitae* written in English;
- self-certified Master's degree document with final mark and exams transcript, or certification of qualification obtained abroad with final mark and exams transcript translated in English. A self-certified translation will be accepted for the purpose of selection;
- certification of any other qualification, such as postgraduate and advanced specialisation degrees, obtained in Italy and/or abroad; a copy of any other qualification considered useful for the purposes of the comparative evaluation. The documentation must be translated in English. A self-certified translation will be accepted for the purpose of selection;
- a list of the publications deemed useful for the purposes of the comparative evaluation;
- an identification document, duly signed;
- fiscal code (for Italian nationals only);
- card-size photograph;
- students with a degree obtained or to be obtained in NON-EU countries shall provide a translation, authentication and a certificate of equivalence of qualification of their foreign degree certificates, issued by the Italian Consulate/Embassy representative offices in the countries where they have obtained/will obtain the degree.

Candidates may also preferably complete their application with the following documents:

- two references letters written in English. The letters shall be sent directly by the writer to the [phd.science@unicatt.it](mailto:phd.science@unicatt.it) within the date of expiration of the present public announcement;
- for non-native speakers of English, a certificate attesting adequate proficiency in English, such as:
  - FCE;
  - CAE;
  - CPE;
  - BEC
  - *British Chamber of Commerce*;
  - *Trinity College*;
  - TOEFL;
  - IELTS;
  - or certificate of the kind deemed useful to prove proficiency in English.

In case of absence of an adequate English proficiency certificate, the Examination panel



will verify the English proficiency during the oral interview.

The application is complete and valid only after having paid the participation fee of € 100.00 (non-refundable) for the selection to be paid online by credit card after uploading the .pdf of the application, which it is generated at the end of the upload path of all documents.

To confirm the successful registration to the selection exam, the candidate will receive a confirmation email from the Università Cattolica del Sacro Cuore Doctorates Office.

The University reserves the right to adopt measures for the exclusion of candidates who do not have the prerequisites required or did not comply with the indications of the public announcement, also after the competition-related examinations have taken place.

Candidates with disabilities, in order to attend the selection examination, must specify in their application the aid required in relation to their disability, in accordance with Italian Law no. 104 of February 5<sup>th</sup>, 1992.

#### **Art. 6**

##### **Examination Panel**

The Examination Panel of the comparative evaluation for admission to the PhD Programme in Science is appointed by Rector's Decree for the competition-related examinations.

For each project/scholarship published within the present call, the Examination Panel will consist of three academics/researchers pertaining respectively to the PhD Research topic.

The composition of the Panels will be published, after the expiration date of the present public announcement, at <https://progetti.unicatt.it/progetti-ateneo-bandi-e-concorsi-milano-piacenza-brescia#content>

In a preliminary meeting the Examination Panels shall define the criteria for the comparative evaluation necessary for a single merit-based ranking to be drawn up. These criteria will be published, as by law enacted, at <https://progetti.unicatt.it/progetti-ateneo-bandi-e-concorsi-milano-piacenza-brescia#content>

#### **Art. 7**

##### **Admission to PhD Programme**

Candidates are admitted to the International PhD in Science according to the ranking, until the established number of positions have been filled.

The results of the competition in the form of a single merit-based ranking will be published at <http://dottorati.unicatt.it/concorsi-milano>



**Art. 8**  
**Enrolment**

The winners of the competition must complete the registration within 5 days starting from the day following the one in which the related email with the invitation will be received, by accessing the following website: <https://iscrizioni.unicatt.it/iscrizioni/>

**Art. 9**  
**Aid and studentships**

Tuition fees for the International PhD in Science at Università Cattolica del Sacro Cuore are set annually by the Board of Directors.

PhD students are required to pay tuition fees annually amounting to € 1,516.00, to be paid in three instalments: the first (of € 516.00) upon enrolment, the second (of € 500.00) by February 28<sup>th</sup>, and the third (of € 500.00) on June 30<sup>th</sup> each year.

For the Italian law, a scholarship on the PhD programme is compatible with other income (also earned on a regular basis) in the calendar year of the scholarship, provided that such income does not exceed the scholarship itself. Should these income limits be surpassed, the scholarship shall be revoked for the year in question. Students with scholarships shall annually declare the income and notify of any excess of the prescribed limits.

The scholarships are renewed annually, provided that the PhD students have completed the programme of activities set for the previous year.

The amount of the studentship, paid in monthly instalments, is € 16,243.00 per year, before social security charges. The studentship is subject to the payment of social security contributions (INPS specific management) pursuant to Art. 2, Paragraph 26, of Italian Law 335 dated of August 8th, 1995, and subsequent amendments. The studentship is exempt from local income tax and personal income tax (IRPEF).

The studentship amount shall be increased by max. 50%, for a period not over 12 months pursuant to Art. 9, Paragraph 3 of the Ministerial Decree 226/21, if the PhD student is authorised by the Teaching Panel to conduct research abroad.

Starting from the first year, to each PhD student, with or without a studentship, is granted a sum covering research activities in Italy and abroad amounting to 10% of the annual gross amount of the studentship, equal to € 1,624.30.

**Art. 10**  
**Public employees**

Current Italian legislation on leave of absence or special leaves applies to public employees admitted to International PhD in Science.



**Art. 11**

**Obligations of PhD students**

PhD students are required to take part regularly in the activities set out in their curricula, and to commit to the regulatory norms of their University of enrolment.

**Art. 12**

**Conferment of PhD degree**

The procedure of PhD degree conferment is governed by the regulatory norms of the University of enrolment.

**Art. 13**

**Public disclosure**

This public announcement is published on the *Euraxess* European website, on the MIUR website and at: <https://progetti.unicatt.it/progetti-ateneo-bandi-e-concorsi-milano-piacenza-brescia#content>

**Art. 14**

**Final provisions**

For any matter not explicitly contemplated in this public announcement, the provisions indicated in the Regulatory Norms of the University of PhD students' enrolment shall apply.

Head of the procedure of the present selection is Dr Roberto BRAMBILLA, Director of Postgraduate Education and Research Partnership, Via Carducci 28/30, Milan, Italy.





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ANNEX sub. 1  
Rectoral Decree No. 8833 of 28<sup>th</sup> June 2022

## **Allocation of additional resources under the National Recovery and Resilience Plan (PNRR) to accredited pathways in the 38<sup>th</sup> cycle**

As regards the public competition for the International PhD in Science of Università Cattolica del Sacro Cuore – Brescia Campus, additional resources provided by the National Recovery and Resilience Plan (PNRR) are available for the following PhD program:

### **International PhD Programme in SCIENCE**

Coordinator: Professor Prashant V. KAMAT - University of Notre Dame, Indiana (United States of America).

Duration: 4 years

#### Posts with scholarship pursuant to Ministerial Decree 351/22:

- No. 1 scholarship for the realisation of the research project on “Supersonic cluster beam synthesis of innovative transition metal oxides photoelectrodes for hydrogen production” under the topic “Tematiche PNRR”.

#### Posts with scholarship pursuant to Ministerial Decree 352/22:

- No. 1 scholarship for the realisation of the research project on “Biomarker sensing for precision medicine in digital healthcare”, co-financed by Antares Vision S.p.a., Travagliato (BS);
- No. 1 scholarship for the realisation of the research project on “Studio di un sistema di ispezione real time basato su infrarossi e THz da accoppiare ad un sistema di ispezione multi energia a raggi X per applicazioni nel settore alimentare ed automotive” (“Study of a real time inspection system based on infrared and THz to be combined with a multi-energy X-ray inspection system for food and automotive applications), co-financed by Xnext S.p.a., Milan
- No. 1 scholarship for the realisation of the research project on “Biomolecule mapping and identification via optical microscopy technique”, co-financed by Perseus Bionics BV, Thienen, Belgium.



Nomina dei membri del collegio dei docenti del corso di Dottorato internazionale in *Science*, con sede amministrativa presso l'Università Cattolica del Sacro Cuore in accordo con la *Katholieke Universiteit Leuven (Belgium)*, la *Pontificia Universidad Católica de Chile Santiago (Chile)* e l'*University of Notre Dame du Lac - Notre Dame, Indiana (USA)*, – ciclo XXXVIII

Collegio dei docenti:

- Prof. Prashant V. KAMAT - University of Notre Dame du Lac, Indiana – Coordinatore;
- Prof. Luca GAVIOLI, Università Cattolica del Sacro Cuore;
- Prof.ssa Stefania PAGLIARA, Università Cattolica del sacro Cuore;
- Prof. Mauro SPERA, Università Cattolica del Sacro Cuore;
- Prof. Marco SQUASSINA, Università Cattolica del Sacro Cuore;
- Prof. Daniele TESSERA, Università Cattolica del Sacro Cuore;
- Dott. Riccardo MARZUOLI, Università Cattolica del Sacro Cuore;
- Prof. Francesco BANFI, Università di Lione (FRANCIA);
- Prof. Alejandro CABRERA, Pontificia Università del Cile (CILE);
- Prof.ssa Patricia CLARCK, University of Notre Dame du Lac, Indiana; (STATI UNITI D'AMERICA);
- Prof. Steven DE FEYTER, Università Cattolica di Lovanio (BELGIO);
- Prof. Giuseppe DE NITTIS, Pontificia Università del Cile (CILE);
- Prof. Jan ELSSEN, Università Cattolica di Lovanio (BELGIO);
- Prof. Greg HARTLAND, University of Notre Dame du Lac, Indiana;
- Prof. Boldizsar JANKO, University of Notre Dame du Lac, Indiana;
- Prof. Masaru KUNO, University of Notre Dame du Lac, Indiana;
- Prof. Walter LUYTEN, Università Cattolica di Lovanio (BELGIO);
- Prof. Jeronimo MAZE, Pontificia Università del Cile (CILE);
- Prof. Enrique MUNOZ, Pontificia Università del Cile (CILE);
- Prof. Lino PEREIRA, Università Cattolica di Lovanio (BELGIO);
- Prof.ssa Sylwia PTASINSKA, University of Notre Dame du Lac, Indiana;
- Prof. Riccardo RAABE, Università Cattolica di Lovanio (BELGIO);
- Prof. Roberto RODRIGUEZ, Pontificia Università del Cile (CILE);
- Prof.ssa Flavia ZACCONI, Pontificia Università del Cile (CILE);
- Prof. Marco ZAMBON, Università Cattolica di Lovanio (BELGIO).

