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CEFIPRA

INSTITUT FRANÇAIS India

Job offer – Post-doctorate in self-powered electrochromic materials and devices for smart windows applications

Research Project Short Title as Submitted to CEFIPRA: "Photo-assisted electrochromic smart window for all weather conditions: from fundamental aspects to building prototypes"
Principal Investigator contact: "Dr. Anthony Maho, anthony.maho@icmcb.cnrs.fr", Institut de Chimie de la Matière Condensée de Bordeaux – Université de Bordeaux
Reference Number of the Job Offer: IFI_CEF_24_12

Project description:

- **Keywords:** Smart Windows, Electrochromics, Photo-conversion, Sustainable buildings, Energy harvesting and Storage, Plasmonics and Opto-ionics

- **Context:**
  Buildings are known to be responsible for over 40% of global energy use and 36% of global greenhouse gas emissions. Therefore, realizing the lofty goal of decarbonization by 2050 depends heavily on the improvement of their energy efficiency. Electrochromic (EC) smart windows can change their colour in response to an external DC voltage, providing dynamic management of the lighting and thermal loads in buildings. Overall, using EC windows might reduce yearly energy consumption by up to 30%, and their benefits in order to reduce energy have been proven even compared to the superior heat insulation windows. Thus, their use can contribute to the transition to a building stock that is extremely energy-efficient and climate neutral. Lower cost processing techniques, additional features of spectral selectivity, and self-power operation should be incorporated in order to increase their cost-to-performance ratio.

- **Abstract of the Research Project:**

  Modern architecture's glass windows are thought to be the least energy-efficient, wasting more than 40% of the energy that could be conserved. To solve this issue, smart windows have been proposed, being able to regulate light and heat exchanges between indoor and outdoor spaces based on the needs of the user. Although using electrochromic smart windows (ESWi) is an excellent way to save energy, it still needs an external power source to operate and cannot regulate near-infrared (NIR) transmittance effectively. The energy consumption of buildings can be further reduced if the solar light that shines on windows can be used to power the colouring of ECWs by band matching of EC films to achieve photovoltaic conversion. To this end, this project is addressing the development of solar-light-assisted electrochromic devices that do not require an external power source to change the transmittance. Such self-powered photoassisted electrochromic smart windows (PESWi) deftly control the transmittance utilizing the incident sunlight, with one function allowing to modify the device's chromatic characteristics in response to sunlight and another involving the conversion of sunlight into electrical energy. In terms of optical selectivity, the use of a NIR-selective electrode made of plasmonic tin-doped indium oxide (ITO) nanocrystals (NCs) will further regulate the transmission of NIR radiation without impacting the visible light transmission, ultimately enabling multiple operating states instead of conventional two states (i.e., clear and dark), which will make the PESWi compatible to all weather conditions. The project will gather partners from India, Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR) and Centre for Nano and Soft Matter Sciences (CeNS) in Bangalore, and France, Institut de Chimie de la Matière Condensée de Bordeaux (ICMCB) – Centre National de la Recherche Scientifique (CNRS).

- **Scientific Objectives of the Project:**

1. Development and designing of a suitable combination of photo-active layers (WO3, MoS2, and MoSe2) on transparent conducting electrodes (TCE) by physical and solution processes to achieve photo-conversion efficiency (> 2%) using the concept of band engineering.

Addressed by JNCASR, CeNS

2. Development and integration of plasmonic nanomaterials based on ITO formulations so to provide PESWi with advanced dual-band VIS-NIR modulation capacities.

Addressed by ICMCB-CNRS

3. Detailed photo-electrochromic evaluation of developed electrodes in three electrodes configuration with suitable electrolyte and understanding of their structural and coloration mechanism.

Addressed by JNCASR, CeNS & ICMCB-CNRS

4. Identification of the suitable combination of materials for the photo-electrochromic electrode and development of a working prototype with transmittance modulation at 550 nm (ΔT) > 50% on exposure to solar irradiance (1000 W/m^2) capable of operating in multiple states such as visible transparent + NIR transparent, visible transparent + NIR blocking, visible blocking + NIR blocking, visible blocking + NIR transparent, visible semi-transparent + NIR blocking, etc.

Addressed by JNCASR, CeNS & ICMCB-CNRS

- **Methodology and Timeline of the Project:**

At ICMCB-CNRS in France, the use of plasmonic ITO nanocrystals as NIR-modulating electrochromic materials will allow to regulate heat transfers in (photo-)electrochromic devices selectively from visible light contributions, making them possible to attain five states of optical filtration in smart windows (clear / warm / clear cool / cool / dark modes) instead of two (clear / dark) and consequently all-weather compatible. Based on its expertise in electrochromic devices assembly, ICMCB will foster the integration of stable and efficient formulations of electrolyte materials being compatible with the photoanode and photocathode configurations, ultimately allowing for high efficiency in photo-conversion and electrochromic functionality in solid-state prototypes of PESWi.

ICMCB has specific expertise in the combination of materials of optimized performance by adjusting the structure, composition and morphology to the film processing and of the design of specific architecture of devices, addressing several applications (smart windows, labels, electrochromic dials for connected objects). The lab facilities offer a wide range of techniques both on synthesis (powders and films) and characterizations such as STEM, XRD, profilometry, TGA-DSC, electrochemistry (cyclic voltammetry, chrono-amperometry, impedance spectroscopy), optical spectroscopy (transmittance, reflectance) etc.; in-house coating techniques include spray, spin, doctor blade, serigraphy and RF sputtering.

Timeline: by year 1, synthesis and characterization of ITO nanocrystals, optimization of wet deposition on transparent conducting electrodes, photoelectrochemical studies on individual electrodes; by year 2: selection and optimization of suitable electrolytes and assembly into pre-prototypes, followed by photo-electrochemical studies.

Candidate profile

- Indian candidates or candidates with a research experience in India are eligible; French candidates are not eligible
- No competences in French language is required
- Candidate competences
    - You have a background in inorganic chemistry, electrochemistry and/or surface science.
    - You have experience with nanoparticles synthesis and surface modification, consecutive film wet processing by spin/spray coating, and characterization; relevant experience with plasmonic and/or

electrochromic materials is a big plus; knowledge of modelling tools and strategies is a plus.
    - You can easily integrate in an interdisciplinary team with diverse backgrounds.
    - You are able to report and to present scientific results (publications, conferences …).
    - You have an excellent command of the English language and excellent communication skills. Working knowledge of French is an asset.
- Candidate know-how
    - Processing of inorganic metal oxides as nanoparticles, colloids, thin films and devices.
    - Characterization of the chemical/physical/optical/electrochemical properties of the processed materials, towards the design of electrochromic systems testifying for self-powered capacities.
    - Show both leadership and willingness to push forward new ideas for improving the process and performances of the electrochromic materials.
    - Publish in high-impact scientific journals and communicating in major conferences in the research field.
    - Interact with national and international collaborators from academy and industry.
- Expected starting date: **01-10-2024**
- Expected duration: **12 months**

How to apply?

Documents to be provided :

i. A cover letter (reasons for the candidature, professional project …) max 2 pages
ii. A copy of the master's degree or a proof of the program followed (and expected date of end) OR A copy of the PhD degree or a proof of the PhD program followed (and expected date of defense) max 1 page
iii. A copy of results for previous scholarship (max 3 pages)
iv. International curriculum vitae (max 2 pages)
v. Two letters of recommendation: one from any Indian institution and one from the French institution planned to host the candidate –mandatory- (max 2 pages)
vi. All should be submitted within 1 pdf file of no more than 10 pages.

Applications should be submitted to the following email address: msi@ifindia.in mentioning the reference number of the Job offer clearly.

Final approval of the selected candidate depends on passing security checks by ICMCB and CNRS headquarters.

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Candidates are requested to contact the French scientific principal investigator of the project before submission. A recommendation letter from the scientific principal investigator is mandatory.

Benefits:

- Monthly allowance of 2400 euros for Post-Doc
- Travel allowance
- University fee
- Carte de séjour fee
- Campus France management fee
- Registration to the French social security scheme

Selection process:

Selection is made by a dedicated selection committee of at least 4 persons. Decisions will be transmitted by the Embassy of France to CEFIPRA. **No consideration will be given for candidates with no recommendation letter from the French institution.**

Criteria for applicants' selection:

Academic excellence

- Excellence of the Academic background, Academic records, Honors, Letters of support, Participation to international research projects, exchange programmes and conferences.

Motivation and qualities

- Academic maturity: appropriation of the thesis project (stakes and contexts) • Quality of the presentation (oral expression, skills for synthesis, English level) • Maturity of the professional project: capacity to project her/himself within five years in terms of career development.

About CEFIPRA:
Indo-French Center for the Promotion of Advanced Research (CEFIPRA/IFCPAR) is an Indian body which promotes scientific cooperation between France and India in advanced fields of Science and Technology. It is supported by the Department of Science and Technology, Government of India and the Ministry of Europe and Foreign Affairs of the French government.