Doctoral position at Ecole Polytechnique

Carbon Nanotube Based Sensor array for water contaminants detection: heavy metals and pesticides detection

Background

The proposed doctoral position will take place within the European-Indian Project LOTUS coordinated by Ecole polytechnique and dedicated to the fabrication of “LÓw-cost innovative Technology for water quality monitoring and water resources management for Urban and rural water Systems in India”.

India is facing a water and sanitation crisis. While a staggering 17% of the world population resides in India, the country’s share of world water resources is small — only 4% — which creates a significant gap between water demand and availability. Furthermore, given that 80% of the country’s water is used for irrigation, only 20% is available for drinking water and other industrial needs. Only 32% of households have access to a drinking tap water from a treated water source.

Digital water solutions, i.e., integrating ICT to water management, have the potential to improve water quality and availability for municipalities and consumers worldwide. Water quality monitoring, strongly needed, is traditionally slow, expensive and requires specialized personnel. Now it can instead be achieved on a real-time basis with no expertise involved. With focus on co-development between EU and India, LOTUS brings a new ICT solution for India’s water and sanitation challenges in both rural and urban area.

It is based on an innovative multi-parameter, carbon-nanotube-based chemical sensor array for real time, adaptable water quality monitoring of contaminants. This sensor array is developed at Ecole polytechnique, within the NACRE team, a joint research team between Ecole polytechnique, CNRS and IFSTTAR. The device exploits carbon-nanotubes-based resistive chemical sensors with optimized, differentiated chemical functionalizations. Sensitivity to pH, chlorine, chloride, hardness and nitrates has been demonstrated so far.

Principle of operation

Each sensor in the array consists of a conducting network of multi-walled carbon nanotubes (MWCNT) directly ink-jet printed on Silicon between interdigitated electrodes. The MWCNT are functionalized in liquid phase by specific molecules (conjugated polymers) selected for their capability 1) to complex reversibly and selectively the target analytes, 2) to bound non-covalently with the MWCNT 3) to ensure efficient charge transfer between target analytes and MWCNT. When the device is exposed to water containing a mixture of various species, in the absence of functionalization, most species interact with the MWCNT-based devices. In the presence of functionalized MWCNT on the contrary, the devices respond selectively to the targeted analyte thanks to the functionalization.
Proposed research
The proposed PhD project will mostly focus on expanding the capability of the sensor array to selective heavy metal and pesticide detection. Toward this goal, the project will exploit new functionalization molecules developed within the team.

After optimization of the (well-established) device fabrication protocol (MWCNT ink fabrication and ink-jet printing, wire bonding of chips) to account for the new functionalization, the core of the work will consist in extensive characterization of the sensor array in water and with various high resolution equipment (AFM, SEM, Raman, confocal microscopy, absorption and emission spectroscopies...).

The main purpose will be to quantify the sensitivity and selectivity of the sensor array to the new target analytes (heavy metals and pesticides), throughout the life time of the sensors in water. To achieve this goal, the work will include advanced exploitation of characterization data, including via statistical software.

Team & organization
Position located in greater Paris area: Ecole polytechnique, Route de Saclay, 91128 Palaiseau, France.

Work within NACRE research team (IFSTTAR, Ecole polytechnique, CNRS)

The team counts 3 researchers, 2 engineer, 1 technician, 8 to 10 young researchs (interns, PhDs, postdocs) and 2 startup projects. One of these startups (in creation) notably focuses on the commercialization of the sensor array technology for water monitoring.

The candidate will have two PhD directors, Gaël Zucchi & Bérengère Lebental. He/She will have weekly meeting with them, as well as monthly team meetings.

He/She will present his/her work yearly to a PhD committee (2 additional researchers in addition to the 2 supervisors) to help guide the research.

The candidate will have the opportunity to follow classes at Ecole polytechnique and to carry out teaching activities.

Application and deadlines
The successful candidate will have a strong background in material sciences, especially focused toward nanomaterials devices.

Fluent English (written and spoken), high proficiency in technical writing and presentations. Autonomy, spirit of initiative, decision-making skills, creativity, team working ability

To be considered, applications must include detailed resume, motivation letter and all available grades for the current degree being prepared.

Starting date: Adjustable. Ideally 2nd semester 2019

Contacts
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