Post-doc announcement 'Diffusion Of Nanoparticles On Surfaces' *(advanced image processing of 2D/3D Transmission Electron Microscopy images)*

Practical information

- **Post-doc position**
- **Duration**: 18 months starting between February, 1st 2019 and May 31st 2019
- **Net Salary/month**: 2192 € (minor bonus possible depending upon the situation)
- **Location**: Lab. LaHC[1], campus Carnot, University of St-Etienne. Frequent daily missions to Lyon (Villeurbanne, MATEIS[2]/CREATIS[3], INSA de Lyon, about 1 and a half hour by public transportation, cost covered).
- **Supervisor**: Prof. Christophe Ducottet, LaHC, St-Etienne. Co-supervisors: Dr. Thomas Grenier, CREATIS, Prof. Thierry Epicier, MATEIS
- **Recommended skills**:
  .Required: PhD degree in Image processing or Computer Vision and strong programming skills in C++ and matlab or Python
  .Appreciated: any of the following: machine learning, Materials science background, knowledge (and/or practice) of electron microscopy (SEM and/or TEM)
- **Contact**:
  Send an extended CV with research and programming experiences and a detailed list of publications (English) + motivation letter and possible referents to:
  ducottet@univ-st-etienne.fr, thierry.epicier@insa-lyon.fr

Description of the subject

In the frame of the French EUR project SLEIGHT[4], we propose a post-doc position in the frame of the research program **DiONisOS**: **Di**ffusion **O**f **N**anoparticle**s** **O**n **S**urfaces associating 3 labs of the University of Lyon: MATEIS (INSA-Lyon/UCBL), LaHC (St-Etienne) and CREATIS (INSA-Lyon/UCBL).

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[1] The Hubert Curien laboratory - LaHC) is a joint research unit (UMR 5516 CNRS) of the Jean Monnet University, Saint-Etienne, the National Research Centre "CNRS" and the Institut d'Optique Graduate School. Its research activities are organized according to two scientific departments: 'Optics, photonics and microwave' and 'Computer science, telecom and image'. https://laboratoirehubertcurien.univ-st-etienne.fr/en/index.html.

[2] MATEIS (UMR 5510 CNRS) is a Materials Science lab. INSA-Lyon - Université Claude Bernard Lyon I. It encompasses different fields, namely chemistry, physics and mechanics. The MATEIS laboratory studies three classes of materials (metals, ceramics and polymers), and their composites, incorporating their characteristics by volume and surface and their interfaces. https://mateis.insa-lyon.fr/en.

[3] CREATIS (UMR 5220 CNRS, INSERM U1206) is a biomedical imaging research laboratory at Université Lyon 1 - INSA Lyon - Université Jean Monnet Saint-Etienne. its main areas of excellence and international influence are linked to two fundamental problems, namely (i) identification of major health issues that can be addressed by imaging, (ii) identification of theoretical barriers in biomedical imaging related to signal and image processing, modelling and numerical simulation. https://www.creatis.insa-lyon.fr/site7/en.

[4]EUR: École Universitaire de Recherche (Graduate Scholl); SLEIGHT: Surfaces Light Engineering- Health & Society, https://www.univ-st-etienne.fr/fr/tous-les-faits-marquants/annee-2017-2018/zoom-sur/manutech-sleight-lighting-engineering-surfaces-health-society-in-the-framework-of-the-investissement-d-avenir-program-3.html.

The project deals with the characterization of the mobility of a population of nanoparticles (NPs) dispersed on a support, as in the very representative case of heterogeneous catalysis. When submitted to heat treatments under oxidizing or reducing conditions as generally required for conditioning such nanocatalysts, migration, coalescence or growth of NPs has to be avoided since larger sizes usually degrade the catalytic performances.
It is today possible to perform such treatments in situ in a dedicated environmental Transmission Electron Microscope (ETEM[5]) under environmental, i.e. gas (air, oxygen or hydrogen) at high temperature and follow the evolution of the population of NPs in pseudo-real time (according to careful observations conditions limiting the undesirable electron beam effects). Such studies can thus be conducted at the nanometric level in the ETEM on systems such as Pd NPs supported on delta-alumina platelets.
The post-doc will be in charge of developing original image processing methods to:

(i) track accurately and quantitatively the population evolution from in situ sequences of images, i.e. 2D projections recorded in the ETEM (mostly, Scanning TEM micrographs)
(ii) mix 2D with 3D information obtained from the analysis of the surface topography of the support as deduced from stereo-photogrammetry reconstruction using an advanced TEM[6] equipped with a dedicated Secondary Electron detector.

Although the subject is largely inter-disciplinary (electron microscopy, context of catalysis, thermodynamical processes, image processing) which will give the candidate the opportunity to participate to many steps of the project, his/her main tasks will be focused on image processing, including:

- machine learning, deep learning, denoising and tracking approaches (e.g. multi-model particle filters)
- spatio-temporal filtering methods to prioritize information about the NPs history (big data related to events such as: trajectories, disappearance, coalescence/fusion, crossing,…).
- 3D reconstruction

Indicative references (asterisk = from the partners):

[1]* Epicier T. et al., submitted to *Catalysis Today* (under revision). See also https://hal.archives-ouvertes.fr/hal-01934081/file/Mat%C3%A9riaux-2018_Pd-Al2O3_T-Epicier_et-al_%282018-11_Strasbourg%29.pdf.
[2] DeLaRiva A.T., Hansen T.W., Challa S.R., Datye A.K., In situ Transmission Electron Microscopy of catalyst sintering. *J. of Catalysis,* **308** (2013) 291-305. http://dx.doi.org/10.1016/j.jcat.2013.08.018.
[3] Inada H., Su D., Egerton R. F., Konno M., Wu L., Ciston J., Wall J., Zhu Y., Atomic imaging using secondary electrons in a scanning transmission electron microscope: Experimental observations and possible mechanisms. *Ultramicroscopy*, **111** 7 (2011) 865-876. http://dx.doi.org/10.1016/j.ultramic.2010.10.002.
[4] Tondare, V. N., Villarrubia, J. S., Vladár, A. E., Three-Dimensional (3D) Nanometrology Based on Scanning Electron Microscope (SEM) Stereophotogrammetry. *Microsc. & Microanal.*, **23** (2017) 967-977. http://dx.doi.org/10.1017/s1431927617012521 ; see also https://all3dp.com/1/best-photogrammetry-software/.
[5]* Lafaye de Micheaux H., Ducottet C., Frey P., Multi-model particle filter-based tracking with switching dynamical state to study bedload transport. *Machine Vision and Applications*, **29** 5 (2018) 735-747. http://dx.doi.org/10.1007/s00138-018-0925-z.
[6]* Ben salah R., Alata O., Tremblais B., Thomas L., David L., Tomographic Reconstruction of 3D Objects Using Marked Point Process Framework. *J. of Mathematical Imaging and Vision*, (2018), 1-18. https://doi.org/10.1007/s10851-018-0800-6.
[7]* Mure S., Grenier T., Meier S., Guttmann R.G., Benoit-Cattin H., Unsupervised spatio-temporal filtering of image sequences. A mean-shift specification, *Pattern Recognition Letters*, **68** Part 1 (2015) 48-55. https://doi.org/10.1016/j.patrec.2015.07.021.

[5] Microscope FEI - TITAN ETEM, installed at IRCELYON-CLYM, Villeurbanne (www.clym.fr).
[6] Microscope JEOL neoARM, installed at LaHC-CLYM, St-Etienne.