

Chemistry for **E**lectron-Induced **N**anofabrication - CELINA
COST Action CM1301

COST Action CM 1301 (CELINA) has continued to promote the field of FEBID research during the first half of its second year. Our second annual meeting CELINA 2015 took place May 6-9 in Bratislava highlighting the diverse aspects of FEBID as well as what has been achieved during the first year of the Action. We thank Peter Papp and his team for the excellent organisation of this very stimulating event. It has witnessed not only interesting results from STSMs performed during 2014. As a particularly important outcome, several collaborations between participants in precursor synthesis and groups studying the electron-induced processes of these compounds or their use in FEBID have emerged and were presented. More opportunities for teaming up were discussed between the posters and over lunches and dinners as well as during the casual conference excursion to the Bratislava castle. We are happy that as a result, Howard Fairbrother from John Hopkins University (US) who is one of the international leaders in studying electron-induced surface chemistry of FEBID precursors has decided to join CELINA as an International Partner.

New ideas and insight have also resulted from follow-up Working Group Meetings in Sempach (Switzerland) and Lisbon (Portugal). These events have also promoted CELINA within the international CVD and electron scattering communities. We can thus look forward to seeing more STSMs and collaborative work in the near future. The present CELINA newsletter highlights some of the interesting developments. We hope it gives you the taste to continue joining your efforts with CELINA's aims or to make new contacts at upcoming events.



CELINA 2015 at the Bratislava castle

*COST Action CELINA chair
Petra Swiderek*

*COST Action CELINA vice-chair
Cornelis W. Hagen*

*COST Action CELINA STSM manager
Nigel Mason*

*WG1
Electron-induced reactions of FEBID
precursors
Chair: Janina Kopyra
Vice-chair: Oddur Ingolfsson*

*WG2
Synthesis of novel FEBID precursors
Chair: Sven Barth
Vice-chair: Patrik Hoffmann*

*WG3
Application of novel precursors in the
FEBID process
Chair: Ivo Utke
Vice-chair: Roser Valenti*

Highlight publications from CELINA – must read!

- The Action Chair's selection -

- The Beilstein Journal of Nanotechnology has published a thematic issue [Focused particle beam-induced deposition](#) edited by Michael Huth and Armin Götzhäuser. It summarizes recent developments in FEBID and highlights also helium ion microscopy (HIM) that has the potential to develop into a similarly powerful tool for nanofabrication

- The prospect of using bimetallic precursors to precisely control the composition of a FEBID deposit has been explored jointly by the groups of Sven Barth (WG2) and Michael Huth (WG3):

Direct writing of CoFe alloy nanostructures by focused electron beam induced deposition from a heteronuclear precursor

F. Porrati, M. Pohlitz, J. Müller, S. Barth, F. Biegger, C. Gspan, H. Plank, M. Huth arXiv:1506:07311 (2015)

- He droplets and cluster experiments reveal how the molecular environment modifies electron-induced precursor fragmentation:

Electron-Induced Chemistry of Cobalt Tricarbonyl Nitrosyl (Co(CO)₃NO) in Liquid Helium Nanodroplets

J. Postler, M. Renzler, A. Kaiser, S. E. Huber, M. Probst, P. Scheier, A. M. Ellis

J. Phys. Chem. C, DOI: 10.1021/acs.jpcc.5b05260

Acetone and the precursor ligand acetylacetone: Distinctly different electron beam induced decomposition?

J. Warneke, W. F. Van Dorp, P. Rudolf, M. Stano, P. Papp, S. Matejcek, T. Borrmann, P. Swiderek

Phys.Chem.Chem.Phys. (2015) 17, 1204-1216

- Post-deposition treatment significantly improves the properties of Cu deposits fabricated by FEBID using Cu(II) (hfac)₂ and similar precursors:

Formation of pure Cu nanocrystals upon post-growth annealing of Cu–C material obtained from focused electron beam induced deposition: comparison of different methods

A. Szkudlarek, A. Rodrigues Vaz, Y. Zhang, A. Rudkowski, C. Kapusta, R. Erni, S. Moshkalev, I. Utke

Beilstein J. Nanotechnol. (2015) 6, 1508–1517

- What needs to be achieved to advance FEBIP technology as a complementary technique to established electron beam lithography?

The future of focused electron beam-induced processing

C. W. Hagen

Appl. Phys. A (2014) 117, 1599–1605

- A review paper from our US external experts summarizes current insight in electron-induced precursor chemistry and discussed strategies for the design of novel precursors:

Understanding the electron-stimulated surface reactions of organometallic complexes to enable design of precursors for electron beam-induced deposition

J. A. Spencer, S. G. Rosenberg, M. Barclay, Y.-C. Wu, L. McElwee-White, D. H. Fairbrother

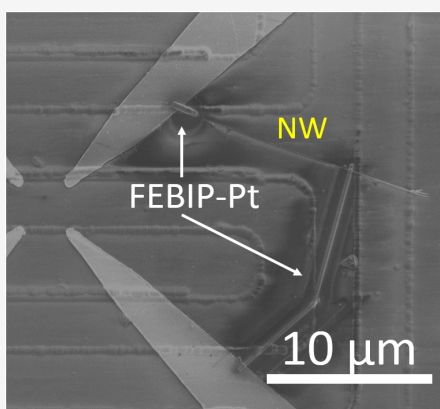
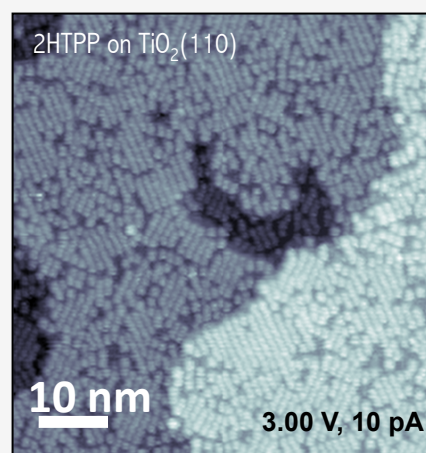
Appl. Phys. A (2014) 117, 1631–1644

More publications from CELINA can be found on our website. Please always remember **to send your new publications to the Chair!**

News from the STSMs

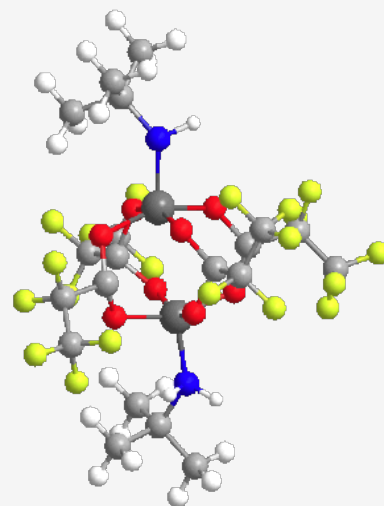
Short-term scientific missions (STSMs) provide excellent opportunities to establish new collaborations but also to use facilities throughout Europe and to pursue new ideas before they are funded on a larger scale. Through STSMs, CELINA establishes links between the scientific communities as assembled in the three WGs. Some selected recent achievements are highlighted here.

To achieve precise spatial control over deposit formation in FEBID precursors must only decompose under the electron beam while surface chemistry must be suppressed. **Imre Szenti** from the University of Szeged (HU) visited the University Erlangen-Nürnberg (DE) to investigate if a single layer of the organic compound 2H-tetraphenylporphyrin (2HTPP) can impede the previously observed non spatially-selective decomposition of $\text{Co}(\text{CO})_3\text{NO}$ on $\text{TiO}_2(110)$. 2HTPP forms dense monomolecular layers according to STM images. In fact, deposit formation is restricted to the area exposed to the beam in the FEBID process. Also, the organic layer can be activated by the electron beam in an EBISA process to initiate autocatalytic growth of deposits in the irradiated area when the precursor is later dosed. The results show that preadsorption of a single organic layer in fact enables a precise spatial control of deposit formation on reactive surfaces.



Device prototyping is an important application area of FEBID. Here, not only the active material but also the electrical connects require improvements with respect to conductivity and thus purity of the connect material. This was also the aim of **Jordi Samà** from the University of Barcelona (ES) who visited FEI (NL) to perform studies on the purification of Pt lines fabricated as contacts to SnO_2 nanowires (NWs) used for sensing applications. The experiments have revealed that post-deposition electron beam treatment of the deposit in the presence of oxygen can successfully remove the majority of carbon impurities. The electrical characterization of the entire sensor assembly is presently performed back in Barcelona to reveal the overall effect of this purification.

CELINA aims at finding novel precursors that perform optimally in FEBID. Therefore, collaborations between synthetic chemists and groups studying FEBID or electron-induced reactions are particularly important. **Iwona Szymanska** from Nicolaus Copernicus University in Toruń (PL) visited the Comenius University in Bratislava (SK) to perform studies on the electron-induced fragmentation of volatile copper(II) carboxylate compounds of the general formula $[\text{Cu}_2(\text{R}'\text{NH}_2)_2(\mu\text{-O}_2\text{CR})_4]$, that had been previously synthesized in Toruń. This STSM has been essential to establish experimental conditions that allow to study this class of compounds but the large variety of available structural variations offers a unique perspective of a long-term collaboration that can unravel the role of specific ligand architectures in precursor fragmentation.



Short Term Scientific Missions – STSMs

STSMs allow participants to make visits to labs in another participating country to initiate new collaborative projects. This year, CELINA still has funds to support several more STSMs. Applications are strongly encouraged. Please contact the Action Chair for information on the current state of our budget. Detailed information on the application process is listed on the CELINA webpage.

Applicant	Host	Project	Dates
Filipe Ferreira da Silva Universidade Nova de Lisboa, (PT)	Stefan Denifl University of Innsbruck (AT)	Dissociative Electron Attachment to WC16	02/02/15 13/02/15
Milos Rankovic Institute of Physics, Belgrade (RS)	Alexandre Giuliani Synchrotron SOLEIL, Paris (FR)	Development of an experimental setup for studies on electron interaction with electro sprayed molecules	04/02/15 25/02/15
Imre Szent University of Szeged (HU)	Hubertus Marbach Universität Erlangen-Nürnberg (DE)	Co(CO) ₃ NO as a precursor on TiO ₂ in FEBIP	01/04/15 30/04/15
Katja Höflich Helmholtz Centre Berlin for Materials and Energy, Berlin (DE)	Ivo Utke EMPA Switzerland, Thun (CH)	Test of novel precursors for copper and silver deposition	01/06/15 31/08/15
Iwona Szymanska Nicolaus Copernicus University, Torun (PL)	Peter Papp Comenius University, Bratislava (SK)	Collisions experiments of the low energy electrons with copper(II) carboxylate compounds	05/07/15 11/07/15
Jordi Sama Universitat de Barcelona, Barcelona (ES)	Piet Trompenaars FEI Electron Optics, Eindhoven (NL)	Gas sensor devices based on purified electron assisted Pt deposition for individual NWs on MHPs	06/07/15 10/07/15

Upcoming events

Forth meeting of Working Group 3
Location: The Hague, Netherlands
Date: during September 21-24, 2015
Mne2015.org

Sixth meetings of Working Groups 2 and 3

Location: Vienna, Austria
Date: to be announced
Jointly with the 6th Workshop on Focussed Electron Beam Induced Processing (FEBIP 2016)
More information following...

CELINA 2016 - The third meeting of COST Action CM1301

Location: Krakow, Poland
Date: to be announced
Jointly with the fifth Meetings of Working Groups 1, 2, and 3 of CELINA.
More information following...