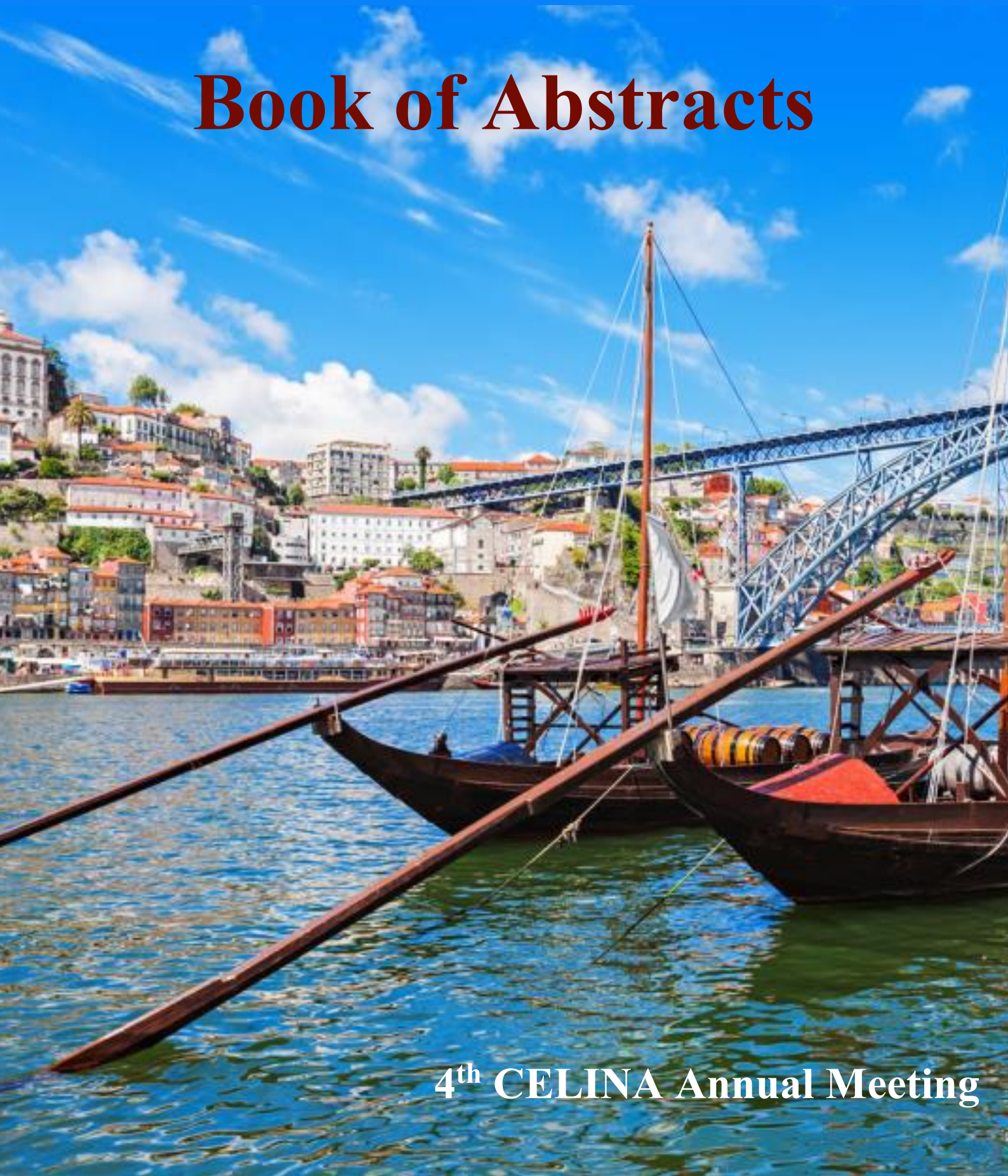
CELINA 2017

cost
EUROPEAN COOPERATION
IN SCIENCE AND TECHNOLOGY

Chemistry for ELectron-Induced NAnofabrication (CELINA)
COST Action CM1301

Porto 13-16 September 2017

Book of Abstracts



4th CELINA Annual Meeting

SCIENTIFIC PROGRAMME OF THE 4th CELINA 2017 annual meeting

Wednesday 13th September

14:00 – 19:00 REGISTRATION AND WELCOME RECEPTION (Seminário de Vilar, Porto)

Thursday 14th September

08:30 – 09:00 **Opening Remarks**

09:00 – 09:20 **CELINA overview and synthetic perspectives**
Chair: Kees Hagen
Petra Swidereck (*University of Bremen*)
"COST Action CM1301 – CELINA: What has been achieved and what lies ahead?"

09:20 – 09:50 **Novel developments in FEBID and beyond**
José Maria de Teresa (*University of Saragoza)*
"Novel developments in FEBID for magnetic materials"

09:50 – 10:20 **Armin Gölzhäuser** (*University of Bielefeld*)
"Imaging, modification and analysis of nanostructures with the helium ion microscope"

10:20 – 10:40 **Teodor Gotszalk** (*Wrocław University of Technology)*
"Novel devices including functional FEBID structures"

10:40 – 11:10 COFFEE BREAK

11:10 – 11:40 **Carboxylate precursors**
Chair Heinrich Lang
Iwona Szymanska (*Nicolaus Copernicus University in Toruń*)
"Overview of properties and synthetic strategies towards carboxylate FEBID precursors"

11:40 – 12:00 **Ivo Utke** (*EMPA – Swiss Federal Laboratories for Material Science and Technology)*
"Gas assisted focused electron beam induced deposition with low volatility precursors"

12:00 – 12:20 **Katarzyna Madajska** (*Nicolaus Copernicus University in Toruń*)
"Perfluorinated silver (I) carboxylate compounds for focused electron beam induced deposition (FEBID)"

12:20 – 12:50 **Lionel Amiaud** (*University of Paris-Sud*)
"New FEBID copper precursor under high vacuum for the study of chemical processes induced by low energy electron irradiation"

12:50 – 14:00 LUNCH

Bimetalic precursors

14:00 – 14:30 Chair: Nigel Mason

Sven Barth (*Technical University of Vienna)*
"Synthesis of heteroleptic and metallic precursors for focused electron beam induced deposition"

14:30 – 15:00 **Oddur Ingólfsson** (*University of Iceland*)
"Electron induced fragmentation of bimetallic focused electron beam induced deposition precursors"

15:00 – 15:30 **Michael Huth** (*Goethe University)*
"Complex 3D magnetic nanostructures prepared by FEBID"

15:30 – 15:50 **Ragesh Kumar** (*University of Iceland*)
"Electron induced surface reaction of bimetal FEBID precursor molecules $HFeCo_3(CO)_{12}$ and $H_2FeRu_3(CO)_{13}$"

15:50 – 19:00 Poster Session
COST Action CM1301 CELINA MC Meeting

Friday 15th September

Neutral excitation and dissociation

09:00 – 09:30 Chair: Oddur Ingólfsson
Juray Fedor (*Czech Academy of Sciences*)
"Neutral dissociation: review of experimental approaches"

09:30 – 10:00 **Matija Zlatar** (*University of Belgrade)*
"The role of electronic excitations in FEBID precursors"

10:00 – 10:20 **Juraj Orzsagh** (*Comenius University*)
"Electron induced fluorescence – detection of neutral fragments"

10:20 – 10:40 **Anita Ribar** (*Comenius University and University of Innsbruck*)
"The role of electron self-scavenging in aggregates of $Cr(CO)_6$"

10:40 – 11:10 COFFEE BREAK

11:00 – 11:40 **Novel developments in FEBID and beyond**
Chair: Armin Gölzhäuser
Gregor Hlawaczek (*Institute for Ion Beam Physics and Materials Research)*
"Nano-fabrication with the helium microscope"

11:40 – 12:10 **CELINA overview and synthetic perspectives**
Lisa McElwee-White (*University of Florida)*
"Mechanism-based design of precursors for FEBID"

12:10 – 12:50 Discussion on future activities
COST Action CM1301 CELINA WG Meetings

12:50 – 14:00 **LUNCH**
14:00 – 19:00 **Walking tour**
19:00 **CONFERENCE DINNER**

Saturday 16th September

09:00 – 09:30
Process gases for deposit purification and lithography
Chair: Ivo Utke
Mostafa M. Shawarav (*Institute of solid state electronics*)
"An overview of in-situ ad ex-situ purification strategies for FEBID gold nanostructures"

09:30 – 10:00 **Anpan Han** (*Technical University of Denmark)*
"Organic ices resists"

10:00 – 10:20 **Markus Rohdenburg** (*University of Bremen*)
"Expanding and understanding water-assisted purification procedures: a case study of the potential FEBID precursor $(EtCp)_2Ru$"

10:20 – 10:40 **Carboxylate precursors**
Katja Höflich (*EMPA – Swiss Federal Laboratories for Material Science and Technology*)
"Direct electron beam writing of silver-based nanostructures"

10:40 – 11:10 **COFFEE BREAK**

11:10 – 11:30
Improved control over electron-driven processing
Chair: Juraj Fedor
Janina Kopyra (*Siedlce University)*
"Low energy electron triggered fragmentation of metal acetylacetonates"

11:30 – 11:50 **Neutral excitation and dissociation**
Sylwia Ptasinska (*University of Notre Dame*)
"Instrumentation for neutral radical detection from gas-phase molecular dissociative electron attachment"

11:50 – 12:10 **Improved control over electron-driven processing**
Gian Carlo Gazzadi (*S3 center – Nanoscience Institute)*
"FEBID of W and Pt precursors at very low energy"

12:10 – 12:30 **Sascha Koch** (*University of Bielefeld)*
"Amplified cross-linking efficiency of SAMs through targeted DEA for production of CNMs"

12:30 – 12:50 **Concluding remarks**
12:50 – 14:00 **LUNCH**
14:00 **Departure**

T-12: Electron induced surface reaction of bimetal FEBID precursor molecules $HFeCo_3(CO)_{12}$ and $H_2FeRu_3(CO)_{13}$

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$HFeCo_3(CO)_{12}$ [1] and $H_2FeRu_3(CO)_{13}$ [2] are precursor molecules used in FEBID to fabricate FeCo and FeRu bimetallic nanostructures, respectively. To date, bimetallic nanostructures have been fabricated in FEBID by mixing two different metal precursor molecules using dual or multichannel precursor gas injection system [3]. However, this approach has limitations to get a good control over the deposit and reproducibility is poor. The use of precursor molecules like $HFeCo_3(CO)_{12}$ and $H_2FeRu_3(CO)_{13}$ in FEBID may offer a rout to eliminate these difficulties.

In fact, nanostructures fabricated with $HFeCo_3(CO)_{12}$ in FEBID have metal content of >80% [1], with excellent reproducibility. In contrast, nanostructures fabricated using $H_2FeRu_3(CO)_{13}$ in FEBID show metal content of only <26% [2]. The different behavior of $HFeCo_3(CO)_{12}$ and $H_2FeRu_3(CO)_{13}$ in FEBID motivated us to study the bond breaking reaction of these precursor molecules adsorbed on a surface, using UHV surface science approach based on X-ray photoelectron spectroscopy (XPS) and mass spectrometry (MS).

From the XPS and MS data, we observed that the initial electron induced surface reactions of $HFeCo_3(CO)_{12}$ and $H_2FeRu_3(CO)_{13}$ are similar, creating a partially decarbonylated intermediate of the form $HFeCo_3(CO)_x$ (x_{avg}~3) and $H_2FeRu_3(CO)_x$ (x_{avg}~4,5), respectively. During typical FEBID experiment, the partially decarbonylated intermediate will experience the effect of either additional electron exposure or transformations initiated by thermal instability. With further electron irradiation, XPS data shows that the CO ligands remained in the $HFeCo_3(CO)_3$ intermediate decompose into C and O but the CO ligands in the $HFeCo_3(CO)_3$ intermediate are thermally unstable at room temperature and desorb almost completely. Consequently, deposits created in FEBD from this precursor will experience the following sequence of elementary reaction steps:

$HFeCo_3(CO)_{12}(ads) + e^- \rightarrow HFeCo_3(CO)_3(s) + 9CO(g)$, $FeCo_3(CO)_3(s) + \Delta \rightarrow FeCo_3(s) + 3CO(g)$

In contrast, additional electron exposure or annealing of the $H_2FeRu_3(CO)_x$ (x_{avg}~4,5) intermediates do not lead to significant CO desorption or CO decomposition. FEBID structures created from this precursor will therefore experience the following sequence of elementary reaction steps:

$H_2FeRu_3(CO)_{13}(ads) + e^- \rightarrow H_2FeRu_3(CO)_x(x \sim 4,5)(s) + 8.5\ CO(g)$,

$H_2FeRu_3(CO)_x(x \sim 4,5)(s) + e^-/\Delta \rightarrow$ most CO ligands are retained

References

[1] F. Porrati, et al., *Nanotechnology* **26**, (2015): 475701.
[2] R. K. T P et al., *Beilstein Journal of Nanotechnology.* (2017): *submitted*.
[3] M. Winhold, et al., *ACS nano* **5** (2011): 9675-9681.

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