



HAL
open science

Networking strategies of the microscopy community for improved utilisation of advanced instruments: , ESTEEM (2006-2011) and ESTEEM 2 (2012-2016) Two European initiatives to support TEM infrastructures and promote electron microscopy over Europe

Etienne Snoeck, G. van Tendeloo

► To cite this version:

Etienne Snoeck, G. van Tendeloo. Networking strategies of the microscopy community for improved utilisation of advanced instruments: , ESTEEM (2006-2011) and ESTEEM 2 (2012-2016) Two European initiatives to support TEM infrastructures and promote electron microscopy over Europe. Comptes Rendus. Physique, 2014, 15 (2-3), pp.281-284. 10.1016/j.crhy.2013.12.002 . hal-01724222

HAL Id: hal-01724222

<https://hal.science/hal-01724222>

Submitted on 7 Mar 2018

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

"Networking strategies of the electron microscopy community for an improved use of the most advanced equipment".

ESTEEM (2006 – 2011) and ESTEEM2 (2012 – 2016): two European initiatives to support TEM Infrastructures and promote electron microscopy over Europe.

Etienne Snoeck
CEMES-CNRS, 29 Rue Jeanne Marvig, 30155 Toulouse Cedex

Gustaaf Van Tendeloo
EMAT, University of Antwerp, Groenenborgerlaan 171, B-2020 Antwerp, Belgium

The ESTEEM project (2006 – 2011)

In 2006, within its 6th Framework Program, the European Commission (EC) has decided to support a 5 years (2006-2011) IP3 project entitled **ESTEEM (Enabling Science and Technology through European Electron Microscopy)** dedicated to transmission electron microscopy (<http://esteem.ua.ac.be/>). The ESTEEM consortium grouped 11 of the major electron microscopy laboratories in Europe over Belgium, UK, Germany, France, The Netherland, Spain, Slovenia and Poland.

The main goals of the ESTEEM project were to promote and develop electron microscopy capabilities over Europe and to offer Transnational Access (TA) to the most advanced electron microscopes to the academic and industrial communities. As a result during the five years' duration of the project, 4,224 days of access to advanced TEM equipment have been provided to 780 users coming from all over Europe through ESTEEM Transnational Access.

Besides facilitating the access to advanced TEM equipment, the European community aims to support workshops and schools to enhance the number of TEM users of the next generation and to train them in the use of quantitative and advanced TEM techniques. ESTEEM has then supported 17 TEM workshops attended by over 700 European participants.

Joint Researches Activities (JRAs) were also part of the ESTEEM project with the aim of supporting progress in the field of Electron Microscopy for the benefit of TEM users. The general JRAs themes were to improve three dimensional imaging of nanoparticles down to the sub-nanometer, and possibly atomic, scale, to push the limits of chemical and electronic mapping in nanostructured materials, to develop improved detection in electron microscopy for rapid acquisition of images and spectra and to develop tools for nanomanipulation experiments inside the electron microscope and apply these tools for the study of dynamic systems. ESTEEM's JRAs were then focussed on electron tomography, electron spectroscopy for mapping electronic structure, holography for mapping fields, new electron detectors developments and new TEM capabilities for *in-situ* experiments. The supported collaborative research activities between ESTEEM partners resulted in a large number of new developments. Many innovative methodologies and tools were indeed developed and cutting-edge results obtained by the ESTEEM consortium. Some of them can be highlighted, as: the new algorithm for discrete tomography reconstruction [1]; the first mapping of plasmons in nanostructures (Figure 1) [2], the discovery of the "Dark field electron holography method" for mapping strain fields [3], the creation of vortex electron beams [4], the combining use of holography and tomography for mapping 3D electrostatic field in devices [5] ...

These innovative results and progress in TEM techniques were transferred to the whole TEM community and most of these advanced methods developed though ESTEEM are now available for any TEM user worldwide. Within the 5 years of the ESTEEM activities 256 papers have been published and 24 patents have been registered by the ESTEEM consortium.

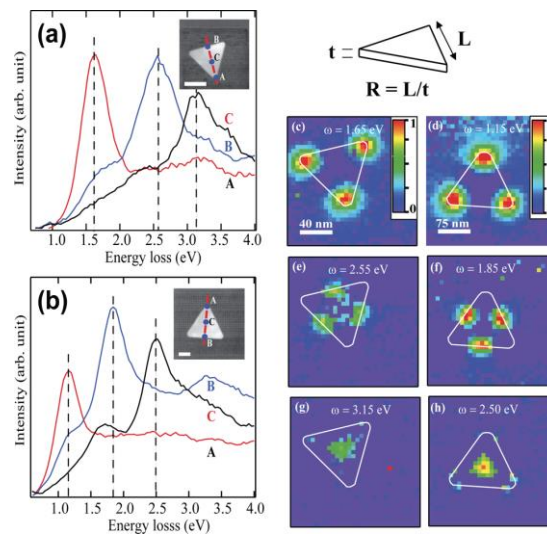


Figure 1: Size dependent mapping of plasmons in silver nanoprisms. EELS spectra acquired at a corner (A), the middle point of an edge (B) and the center (C) of (a) a 97 nm edge-long (thickness 4 nm) (b) and a 176 nm edge-long (thickness 6 nm) nanoprisms, respectively. Reprinted with permission from *Nano Letter* 2010, 10, 902. Copyright 2010 American Chemical Society.

From ESTEEM to ESTEEM2 (2012-2016)

A year after the ESTEEM project ended, the EC decided to support its continuation through an Infrastructure (I3) 4 years project within its FP7 program: **ESTEEM2** (2012-2016) (<http://esteem2.eu/>). Compared to ESTEEM(1), the ESTEEM2 consortium has been extended to new partners in Germany, Sweden, Austria and Spain and two SMEs. The general goals of ESTEEM2 are similar to the ESTEEM(1) objectives: 1) providing open access to the most advanced equipment to the widest possible academic and industrial research community; 2) improving and developing new advanced TEM technics for the benefit of users and the additional goal 3) creating a sustainable infrastructure after ESTEEM2 ends.

Regrouping the equipment of 13 academic partners, European users have access through Transnational Access (TA), to 28 of the most advanced microscopes including 3 double corrected microscopes, several monochromated probe corrected microscopes, few dedicated TEM for various type of *in-situ* TEM experiments, a dedicated probe corrected STEM devoted to EELS experiments, a cold-FEG microscope dedicated to holography and eight FIBs for sample preparation. About 3400 access days are proposed to the ESTEEM2 equipment for the 4 years duration of the project.

After the five years of active developments of ESTEEM(1) in Joint Research Activities, the new consortium has decided to focus the ESTEEM2 JRAs on five main subjects slightly different from the previous JRAs with a similar aim to develop advanced quantitative TEM methods for structural, chemical, electronics and field measurements and to transfer these TEM improvements among partners for the benefit of the users. The first JRA concerns "Quantitative electron diffraction" developments both thanks to new electron precession capabilities but also through CBED and coherent diffraction. The second is devoted to "Imaging" both in high resolution STEM and TEM and EFTEM. It involves the development of methods for quantification and interpretation of (S)TEM images acquired using state-of-the-art instrumentation and techniques. The third JRA is dedicated to advanced "Electron spectroscopies". Its goal is to develop new, versatile EELS techniques and methods and in particular for the study of magnetism, nano-optics and plasmonics all of which have potential industrial applications within EU industry. The fourth is focused on the "3D nanometrology". The objective of this JRA is to obtain precise and quantitative measurements of properties, including chemical composition, magnetic fields and strain distributions, in 3D and in

some cases at the atomic scale in order to provide a better suite of methods that can be applied by academic and industrial users. This JRA combines holography and tomography developments including design and application of new tomography holders, acquisition schemes and reconstruction algorithms. The fifth JRA is slightly different from the previous ones and is devoted to "Time-resolved transmission electron microscopy". It includes the design and development of new fast electron detectors to provide dynamical studies at the millisecond time resolution and of a new hybrid instrument combining a femtosecond laser source and a Transmission Electron Microscope based on a field emission source.

As for ESTEEM(1), besides the TA and JRA activities, ESTEEM2 aims to promote TEM over a scientific community even larger through the organisation of TEM schools and workshops, the creation of fully open data bases with free TEM software, recipes for dedicated sample preparation procedures for "special" objects (hybrids, soft materials...) etc.

ESTEEM(1) has been very successful both in term of advanced TEM developments achieved within this program and in the number of external users who came through TA to perform advanced TEM experiences with the consortium equipment. The academic and industrial communities have largely benefited from this European initiative for the development of their own projects as well as the European "TEM community" which get the opportunity to tighten their connections and collaborative projects and then pushed forward TEM into new innovative topics. These successes drove the EC to support the continuation of ESTEEM(1) with the main goal of giving to Europe the most advanced TEM tools to help the scientific and industrial communities to push forward the capabilities of Europe in science and (nano)technology.

References

- [1] K.J. Batenburg et al., 3D imaging of nanomaterials by discrete tomography, *Ultramicroscopy* **109** (2009) 730–740
- [2] J. Nelayah et al., Two-Dimensional Quasistatic Stationary Short Range Surface Plasmons in Flat Nanoprisms, *Nano Letter*, **10** (2010) pp 902–907
- [3] M. Hytch, et al., Nanoscale holographic interferometry for strain measurements in electronic devices, *Nature*, **453** (2008) 1086
- [4] J. Verbeeck et al., Production and application of electron vortex beams, *Nature*, **467** (2010),
- [5] P. A. Midgley and R. Dunin-borkowski, Electron tomography and holography in materials science, *Nature Materials*, **8** (2009)