

# UC Irvine

## UC Irvine Previously Published Works

### Title

METAMORPHOSE European Doctoral Programs on metamaterials state-of-the-art

### Permalink

<https://escholarship.org/uc/item/3193v45b>

### Journal

IEEE Antennas and Propagation Magazine, 48(6)

### ISSN

1045-9243

### Authors

Capolino, F  
Tretyakov, S  
Bilotti, F  
et al.

### Publication Date

2006-12-01

### DOI

10.1109/MAP.2006.323324

### Copyright Information

This work is made available under the terms of a Creative Commons Attribution License, available at <https://creativecommons.org/licenses/by/4.0/>

Peer reviewed



**David Jackson**

Assoc. Editor, Transnational  
Committee  
Elect. & Comp. Eng. Dept.  
University of Houston  
Houston, TX 77204-4793 USA  
Tel: +1 (713) 743-4426  
Fax: +1 (713) 743-4444  
Email: djackson@uh.edu

**T**he Transnational Committee of the IEEE Antennas and Propagation Society exists to promote the international character of our Society. We encourage all AP-S members to bring to our attention any items of interest that are related to transnational activities.

### Welcome to New Members

The AP-S Transnational Committee welcomes three new members to the committee: Makoto Ando, Magdalena Salazar-Palma, and Amir Zaghloul. Amir Zaghloul will address issues related to technical co-sponsorships of conferences.

The current members of the Transnational Committee are now Makoto Ando, David Jackson (Chair), Juan Mosig, Yahya

Rahmat-Samii, Magdalena Salazar-Palma, Ross Stone, Amir Zaghloul, and Wen Xun Zhang.

### Description of the METAMORPHOSE "European Doctoral Programmes on Metamaterials"

The European program METAMORPHOSE has established an exciting and innovative distributed educational program called the "European Doctoral Programmes on Metamaterials," led by a consortium of 20 European universities. A description of this new educational program, written by the organizers of the Consortium, is given here.

## METAMORPHOSE European Doctoral Programs on Metamaterials State-of-the-Art

***F. Capolino<sup>1</sup>, S. Tretyakov<sup>2</sup>, F. Bilotti<sup>3</sup>, A. Schuchinsky<sup>4</sup>, F. Martin<sup>5</sup>, V. Podlozny<sup>2</sup>,  
A. Sihvola<sup>2</sup>, D. A. Pawlak<sup>6</sup>, I. Vendik<sup>7</sup>, S. Zouhdi<sup>8</sup>, C. Craeye<sup>9</sup>, N. Johnson<sup>10</sup>,  
J. M. Arnold<sup>10</sup>, T. Szoplik<sup>11</sup>, and R. Gonzalo<sup>12</sup>***

<sup>1</sup>University of Siena, Siena, Italy

<sup>2</sup>Helsinki University of Technology (TKK), Helsinki, Finland

<sup>3</sup>University Roma Tre, Roma, Italy

<sup>4</sup>The Queen's University of Belfast, Belfast, UK

<sup>5</sup>Universitat Autònoma de Barcelona, Barcelona, Spain

<sup>6</sup>Institute of Electronic Materials Technology, Warsaw, Poland

<sup>7</sup>St. Petersburg Electrotechnical University, St. Petersburg, Russia

<sup>8</sup>Université Paris-Sud, Paris, France

<sup>9</sup>Université Catholique de Louvain, Louvain-la-Neuve, Belgium

<sup>10</sup>University of Glasgow, Glasgow, UK

<sup>11</sup>Warsaw University, Warsaw, Poland

<sup>12</sup>Universidad Publica de Navarra, Pamplona, Spain

## Abstract

A new European Doctoral Program on Metamaterials has been initiated by the European Union (EU) Network of Excellence METAMORPHOSE. So far, twenty European academic institutions have established a consortium that operates a geographically distributed doctoral school in the emerging and multidisciplinary field of metamaterials.

**Keywords:** Electrical engineering education; metamaterials

## 1. Introduction

The European Commission has funded a four-year project (2004-2008) within the 6th Framework Program (FP6) [1] to support the coordination and integration of research on metamaterials within Europe. This project, called METAMORPHOSE [2] (METAMaterials Organised for radio, millimetre wave, and PHOTonic Superlattice Engineering), is structured as a Network of Excellence (NoE), grouping 23 EU institutions (universities, research centers, and companies, listed in Table 1), distributed all around Europe (Figure 1). The goal of the project is not only the development of new research in the field of metamaterials, but also the creation of an EU METAMORPHOSE Virtual Institute for Artificial Electromagnetic Materials and Metamaterials. This is a professional nonprofit association, with the aim of (a) integrating, managing, coordinating and monitoring EU research in the field of artificial electromagnetic materials and metamaterials; (b) spreading excellence in this field by organizing a scientific congress [3], symposia and conference special sessions, special issues in research journals, and a new research journal, *Metamaterials* [4]; (c) creating and managing joint research programs; (d) establishing and operating training programs (including joint doctoral programs for students and industrial researchers); (e) transferring new technologies to the industry; (f) offering advice and services related to artificial electromagnetic materials and metamaterials to industry, manufacturers, distributors, service suppliers, and to all potential users in Europe and worldwide.

In order to pursue the aforementioned challenging and lasting goals, there is a need to provide comprehensive training of new generations of brilliant students for this wide and multifaceted field. The core METAMORPHOSE researchers, working in various areas (e.g. electrical engineering, materials science, electromagnetics, optics, solid-state physics, etc.), represent the state-of-the-art contributors in this rapidly growing field of metamaterials. Therefore, the students would have an invaluable benefit from a structured and interdisciplinary research training program provided by the leading experts of METAMORPHOSE. To address these needs, the Consortium of the "European Doctoral Programmes on Metamaterials" (in the following, the Consortium) [2] has been formed to operate and support these training programs, and to create lasting education and research integration within Europe.

The main tasks of the Consortium are to develop and operate an integrated but geographically distributed European doctoral school on metamaterials. This consists of three to five week-long events, organized annually at selected EU locations, where focused and cross-disciplinary courses are offered to students trained in the field of metamaterials. Various aspects of metamaterial research, such as material fabrication, nanotechnology, electromagnetic/photonic phenomenology and modeling, industrial applications and designs, etc., are addressed in the courses.

## 2. The Consortium

The Consortium partners, representing 20 EU universities affiliated with the NoE METAMORPHOSE, approved and signed,

in September 2005, a memorandum of understanding (MoU). This established the basic principles of interdisciplinary doctoral training within the Distributed European Doctoral School on Metamaterials, student exchanges, and requirements for conferring the certificate "Mention of Excellence in Metamaterials." The Consortium is composed of the members in the partner universities, the coordinator, and the steering committee.

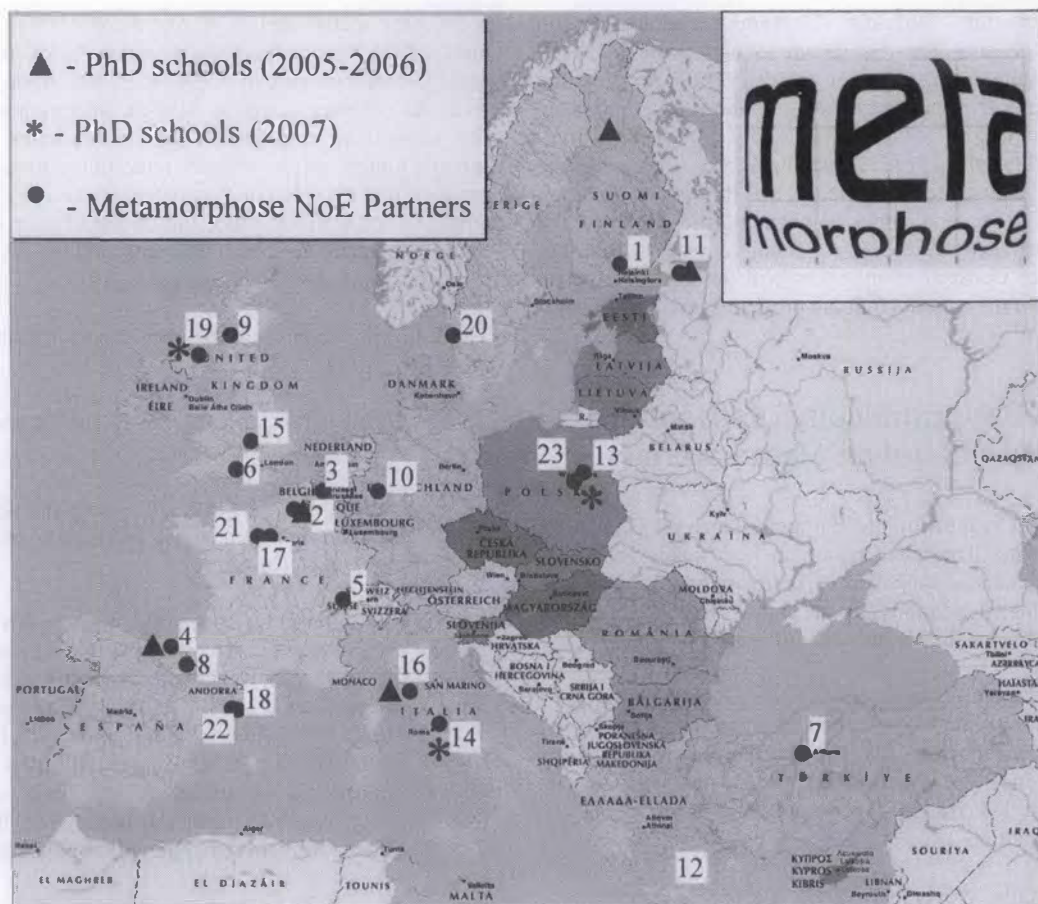
The authors of the present paper are the coordinator of the Consortium, the coordinator of METAMORPHOSE, and the members of the past and present steering committees. The MoU provides the framework for the EU Doctoral Programmes on Metamaterials and regulates the formal procedures. The major requirements to the candidates qualified for the "Mention of Excellence in Metamaterials" are based on the principles of EU educational integration. They hence include:

- Enrolment in any university belonging to the Consortium (the "home" university), which is the degree-awarding institution for the PhD candidates;
- A period of not less than three months in total, spent conducting research in metamaterials in at least one partner university (member of the consortium) other than the home university;

**Table 1. The list of METAMORPHOSE partners.**

1. Helsinki University of Technology, Helsinki, Finland (Metamorphose Coordinator)
2. University of Lille/Centre National de la Recherche Scientifique, Lille, France
3. Université Catholique de Louvain, Louvain-la-Neuve, Belgium
4. Universidad del Pais Vasco, San Sebastian, Spain
5. Swiss Federal Institute of Technology, Lausanne, Switzerland
6. University of Southampton, Southampton, UK
7. Bilkent University, Ankara, Turkey
8. Universidad Publica de Navarra, Pamplona, Spain
9. University of Glasgow, Glasgow, UK
10. Siegen University, Siegen, Germany
11. St. Petersburg Electrotechnical University, St. Petersburg, Russia
12. FORTH, Institute of Electronic Structure and Laser, Heraklion, Greece
13. Warsaw University, Warsaw, Poland
14. University of Roma Tre, Rome, Italy
15. Loughborough University, Loughborough, UK
16. University of Siena, Siena, Italy. (Coordinator Consortium EU Doctoral Programmes on Metamaterials)
17. Université Paris-Sud, Paris, France
18. Universitat Politècnica de Catalunya, Barcelona, Spain
19. The Queen's University of Belfast, Belfast, UK
20. Chalmers University of Technology, Goteborg, Sweden
21. Thales Research & Technology, Paris, France
22. Universitat Autònoma de Barcelona, Barcelona, Spain
23. Institute of Electronic Materials Technology, Warsaw, Poland





**Figure 1. The EU distribution of METAMORPHOSE partners (Table 1). Twenty of them are part of the Consortium of the European Doctoral Programmes on Metamaterials. The distribution of the past doctoral school events (2005-2006), and the planned events (2007) are shown (map elaborated from an original at <http://www.scottish-enterprise.com/euomap.jpg>).**

- A certain number of credit units gained from the attendance of the EU Doctoral School on Metamaterials, organized by the Consortium at various EU locations;
- Journal and conference publications jointly authored with partners affiliated with the Consortium in the field of metamaterials;
- The topic of the doctoral thesis to be in the field of metamaterials.

Finally, the certificate of “Mention of Excellence in Metamaterials” is awarded by the Consortium committee after evaluating the application from candidates who have successfully fulfilled all the prerequisites. The formal recognition of the certificate of “Mention of Excellence in Metamaterials” by the participating universities and wider professional community will represent a further guarantee that such specialized training programs are a vital part of the European educational initiatives.

On the basis of the experience of the school operated during 2005 and 2006, amendments to the first MoU (called MoU-II) have been introduced, and will be offered for approval to the members of the Consortium by the end of 2006. These amendments include:

- “Mutual Credit Acceptance (Integration at EU Level):” principles and rules for acceptance of

credits earned at the EU doctoral school events by home universities, for internal curricula of PhD students, to ensure EU integration;

- “Foreseen interaction with the METAMORPHOSE Virtual Institute for Artificial Electromagnetic Materials and Metamaterials:” the Consortium will be part of this future Institute, and activities shall be coordinated with this association when it is officially created;
- “Admission of new members:” the possibility of accepting external non-METAMORPHOSE organizations as Consortium members, and the rules permitting doing so;
- “Structure of the EU Doctoral School on Metamaterials:” basic rules for running EU Doctoral School events organized within the Consortium;
- “Rules of voting.”

Some EU universities that do not belong to the Network of Excellence have already expressed their interest in joining the Consortium of the European Doctoral Programmes on Metamaterials. As soon as MoU-II is fully approved by the Consortium members, these new partners may enter into the Consortium and participate in the joint activities.

To support the European Doctoral Programmes on Metamaterials, the NoE partners intend to participate in Marie Curie Action Programmes, which are high-level coordinated and structured EU-funded research training programs. The European Doctoral Programmes on Metamaterials today represents a structured and coordinated high-level training core, enhancing the strong cohesion among the universities in Europe working on metamaterials. Having a common agreement (the MoU) and a functionally distributed EU doctoral school represents a further guarantee that the Consortium members will be able to establish the coordination of the national training programs at the EU level.

### 3. The Geographically Distributed Doctoral School on Metamaterials

An important feature of the European Doctoral School on Metamaterials is its distributed nature, in both space and time. Courses are grouped and taught in several sessions each year at different universities/institutions. By the end of October 2006, five school events will have already been held (Figure 1):

1. San Sebastian, Spain, July 2005. Topics: basic concepts, plasmonic resonances, perfect lenses, pairing metamaterials and regular dielectrics, metamaterials for circuits and filters, antenna and circuit miniaturization, theory and models for splitting resonators.
2. Siena, Italy, November 2005. Topics: enhanced radiation and directivity, various metamaterial possibilities for beaming, modeling and design of metasurfaces and high-impedance surfaces, effective parameter characterization of metasurfaces, antenna miniaturization.
3. Lille, France, May 2006. Topics: fabrication and characterization of metamaterial-based structures and devices at THz frequencies, SRRs, nanowires and related particles, structuring crystals and metals, challenges at submicron and nano scales, characterization at THz frequencies.
4. Rovaniemi, Finland, August 2006. Topics: complex material effects in electromagnetics: modeling of dielectric and magnetic properties of heterogeneous materials, effective-medium theories, dispersion models, magnetoelectric effects, wire media, artificial plasmas, origin of negative permittivity and negative permeability, split-ring resonator principles, physical limitations of material parameters.
5. St. Petersburg, Russia, October 2006. Topics: tunable materials: ferroelectrics, ferromagnetics, liquid crystals; tunable metamaterials and metasurfaces; tunable left/right-handed transmission lines; tunable and reconfigurable microwave devices based on metamaterials and left/right-handed transmission lines.

At each event, the relevant experts from the Consortium teach the selected courses, and, indeed, this is the advantage of getting such a large and multidisciplinary Consortium associated with the NoE involved. The topics taught have ranged from theory, phenomenology, and modeling, to nanofabrication and measure-

ments, for metamaterials at microwaves, THz frequencies, and optics. Each School event has attracted 28-35 attendees from various EU countries and, in a few cases, also from the Americas and Asia. As a further extension of the Consortium educational activities, on-demand short courses (one to two hours long), focused on specific topics, will be offered in the future by using a Web learning tool. It is expected that such distance-training tools will be also attractive for industry, since the virtual classes would not require travel of industry personnel, students, and teachers, which can lead to a significant cost reduction.

The following school events are planned for the year 2007 (Figure 1):

1. Warsaw, Poland, May 2007. Topics: metamaterials versus photonic crystals.
2. Belfast, UK, August 2007. Topics: dielectric and plasmonic metamaterials: fabrication, properties and modeling techniques.
3. Rome, Italy, October 2007. Topics: this school will be held together with the First International Congress on Advanced Electromagnetic Materials in Microwaves and Optics [3] organized by METAMORPHOSE. The lectures will be delivered by the key congress speakers, who will address the fundamental problems in the area of artificial electromagnetic materials, along with the practical aspects of microwave and optical applications.

### 4. Conclusions

The METAMORPHOSE Consortium for Doctoral Programmes and Network of Excellence (NoE) create additional opportunities for young researchers for networking, professional self-development, and will help them to find future postdoctoral positions, according to the student's interests and qualifications. This new geographically distributed doctoral school will also bring up well-trained EU experts for the future metamaterials industrial market, and will allow today's students develop their future EU professional network of colleagues working in the same field.

In spite of existing issues regarding the implementation of the EU common educational standards, our doctoral school has been shown to be a big success, because of the active work of the NoE and Consortium members and the goodwill and support of the participating institutions and the university schools. The intention of the Consortium is not to average the level of education in the participating institutions and countries, but to maintain the highest standards in the framework of EU integration. This brings benefits to both the students and the universities, by asserting the top international level of their research and education. We also welcome experts in metamaterial research outside of the Consortium who are interested in contributing to teaching in our distributed doctoral school. The Consortium works toward easy access to the school's materials for the general public. The school's teaching materials are already available to all partner institutions on a shared basis.

Please forward all inquiries to Prof. Filippo Capolino (e-mail: [capolino@dii.unisi.it](mailto:capolino@dii.unisi.it)), and see our EU doctoral school Web pages for more information [2].



## 5. Acknowledgment

The authors are grateful for the support of the EU-funded project METAMORPHOSE (FP6/NMP3CT-2004-500252) and to the collaborative efforts of the EU Project Officer Anne de Baas.

## 6. References

1. METAMORPHOSE is funded by the Framework Program 6 (FP6), thematic area "Nanotechnologies and nano-sciences, knowledge-based multifunctional materials and new production processes and devices" (NMP). Web site: <http://cordis.europa.eu/nmp/home.html>.
  2. METAMORPHOSE Web site: <http://www.metamorphose-eu.org>.
  3. Metamaterials' 2007 First International Congress on Advanced Electromagnetic Materials in Microwaves and Optics, organized by METAMORPHOSE. Web site: <http://www.metamorphose-eu.org/Congress>.
  4. *Metamaterials*, a new peer-reviewed scientific journal organized by METAMORPHOSE, published by Elsevier, ISSN: 1873-1988.
-