

## Hands-on training in Nonimaging Optics for SME's: the SMETHODS experience

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### Summary

A 5-day training in Nonimaging Optics for European SME's employees was carried out in June 2012 in the framework of the FP7 funded Support Action "SMETHODS". The training combined theoretical introduction and hands-on practice. The experience was very positive, and the lessons learned will improve the next scheduled sessions.

### Introduction

The FP7 funded Support Action "SMETHODS" [1] is an initiative of seven European academic institutions to strengthen Europe's optics and photonics industry, which has started on 1 September 2011. Participation in training sessions is free for participants, who are selected with priority will be given to employees of small and medium sized European enterprises (SMEs). The consortium in SMETHODS is formed by seven partners that are the most prominent academic institutions in optical design in their countries. Through fully integrated collaborative training sessions, the consortium provides professional assistance as well as hands-on training in a variety of design tasks in four domains: (1) imaging optics, (2) nonimaging optics, (3) wave optics, and (4) diffractive optics. For each of this domains domain, 5-day training sessions are scheduled to be hold in different locations throughout Europe, four times in two years, the teach four times in a 2.5 years period.

### Training in nonimaging optics: Selected program

The Universidad Politécnica de Madrid (UPM) is in charge of the coordination of training domain 2. The objective is to provide an understanding and a professional knowledge of optical systems used for high-efficiency light transfer with prescribed illumination characteristics rather than optical imaging, covering all major classes of applications in illumination, display systems, solar energy, and light coupling functions.

The full session consists of 5 consecutive days, 6 hours per day. The detailed program is shown in Table 1. The work is organised in 1.5 hours slots, and there contents can be grouped in three categories:

- **Theory:** This consists essentially in lectures, covering the fundamentals, the different design methods, and two important applications, Concentration Photovoltaics (CPV) and Solid State Lighting (SSL). This lessons occupy the following percentages of the 5 days: 75%, 75%, 0%, 25%, 25%
- **Hands-on practice:** Trainees work on with computers on real design problems, proposed by the instructor, using several design software tools (Lighttools, ASAP, Essential MacLeod, Rhinoceros, Mathematica, MS Excel) and with various desing

methods (string method, SMS, differential equations). These lessons occupy 25%, 25%, 100%, 50%, 50%, with progressive difficulty.

- **Industrial lectures:** Two invited speakers from the industry (O. Dross, from Philips Lighting; and R. Mohedano, from LPI ) shared their experience with the trainees. This occupied 25% of the last two days.

Table 1. Detailed program

<b>Monday, June 18 2012</b>	
Lecture	Welcome and Opening remarks
Lecture	1.1. Introduction to nonimaging optics, geometrical optics and basics of photometry
Lecture	1.2. Phase space representation. Etendue invariants.
Hands-on	1.3. Introduction to nonimaging design and analysis with commercial software (I).
Lecture	1.4. Design problems in nonimaging systems.
<b>Tuesday, June 19 2012</b>	
Lecture	2.1. String and flow line design methods.
Lecture	2.2. SMS design method.
Hands-on	2.3. Introduction to nonimaging design and analysis with commercial software (II).
Lecture	2.4. Differential equation methods and multi-parameter optimization methods.
<b>Wednesday, June 20 2012</b>	
Hands-on	3.1. Case studies with LightTools.
Hands-on	3.2. Design of multilayer coatings to combine and split light.
Hands-on	3.3. Matlab and MS Excel as nonimaging optics design tools.
<b>Thursday, June 21 2012</b>	
Lecture	4.1. Introduction to CPV
Hands-on	4.2. CPV Fresnel lens primary mirror and kaleidoscope homogenization
Visit	Visit to CPV installations at ETSIT-UPM
Lecture	4.3. Invited talk: "CPV optics: marrying high performance, reliability and low costs"
Hands-on	4.4. CPV case study based on a primary mirror and a Köhler homogenization.
<b>Friday, June 22 2012</b>	
Lecture	5.1. Introduction to Solid State Lighting (SSL).
Hands-on	5.2. Color mixing in LED projectors.
Hands-on	5.3. SSL color mixing for high luminance lamps.
Lecture	5.4. Invited talk "Beat the bulb"

## Results

The first training session has been hold at the Universidad Politécnica de Madrid from June 18 to 22. The number of attendees was limited to 18 to give a close attendance in the hands-on exercises. The selected candidates came from 8 different countries. The main lesson learned is that for the hands-on practice the instructor and attendees must preferably be doing the exercise simultaneously, and that for a long exercise, the instructor must provide the attendees the correct solution file to guarantee they can follow to the next step (in case they did not succeed to arrive at that point).

The feedback from the trainees was very positive. They were asked to fill an evaluation form the last day, grading from 1 (low) to 5 (excellent) a variety of aspects, from the specific (each individual lecture) to the generality (organisation, lectures and hands-on training, catering, etc). The average mark was 4.14 for the specific questions and 4,40 for the global ones.

## References

- [1] [www.smethods.eu](http://www.smethods.eu)