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## **Teaching Thin Film Optical Coatings**

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### **Abstract**

As the rate of technological change accelerates, continuing education becomes more important than ever. This talk is an account of a successful continuing professional-education course on optical coatings. The course emphasizes understanding and is a mixture of formal lectures and practical computing. Some of the techniques used in the course are described along with some general observations about student capabilities and continuing education in general.

### **Keywords**

Continuing education, thin-film optics, short courses.

### **Summary**

I am an educator rather than educationist. This account is based on my teaching experience rather than the results of research into training. The opinions expressed are personal and specifically directed towards optics and especially thin films.

Education is roughly a process of learning from experience, often someone else's experience, and frequently in a structured fashion, when an instructor may play an important role. There is also an element of developing one's capabilities so as to achieve one's potential. It is not simply a human pursuit. Animals and birds in the wild need education. Without it they would not survive.

We tend to concentrate on education of the young as a preparation for life. Early education, of course, is important from the point of view of survival, and also takes advantage of the enormous capacity for learning in the very young. Much less attention is paid to education once an individual has reached maturity. At that stage one often continues to learn simply by experience. This makes much sense when we are dealing with a reasonably stable environment. Nowadays, however, the environment is changing rapidly and this is especially true of the work environment. These changes can now be so fast as to make it frequently impossible to learn simply by experience. The problem is even worse when certain, no-longer-required skills must be replaced by completely new ones. At least part of the answer is a program of continuing education and it is in this area, and particularly concerning optical coatings, that I have largely been working in recent years.

Formal education at high-school or university level is inextricably entwined with testing. Great importance is attached to the certification of the individual as successfully educated, to the extent that the certification can take precedence over education. The test area must be constrained, hence the attention paid to the syllabus.

The type of instruction with which I am now involved is principally directed towards enhanced abilities and improved confidence, and can be described as pure education. The subject is optical coatings. The students are largely mature professionals ranging over all age groups, with a wide range of scientific and/or engineering qualifications, the levels of which vary enormously. They include people new to the field and workers with many years of

experience. Their objectives range from specific to general, often to improve their effectiveness in their present job, or to be better able to tackle some problem, to find a job, or even just to put what they already know in perspective.

Most of our participants come from companies. Our experience is that companies will rarely permit workers to attend courses longer than one week. We also find that one day is proportionally less productive than multiple days. Apart from the problems of orientation it seems that people need to sleep on the problems. Inhibitions need to be relaxed. So our courses generally last three to five days.

Class size varies, usually lying between ten and twenty. We do, from time to time, teach single individuals but our strong impression is that teaching a group is much more effective. There is a very definite increased positive response from students in a group, especially if a diverse one. We prefer not too many students from one company in one course, unless specifically for a single company, because they usually already know each other and are less liable to mix with others.

Reinforcement is very important. Questions during the lectures help greatly with reinforcement and increase student confidence. Networking is encouraged and usually takes a second day to establish effectively, another reason why we prefer multiple days. We also find computing sessions useful as reinforcement. We believe it important that we provide lunch on the courses. Eating lunch together encourages networking, and also gives students the opportunity for asking general questions.

For accurate calculations we use computers and so computing is included. However, the course emphasis is on understanding. We make sure that fundamentals are adequately covered. We usually begin with revision of complex numbers and the complex plane and find that even students with advanced degrees appreciate this. We explain the fundamentals of complex harmonic waves. We make sure that the physical difference between characteristic admittance and refractive index is understood. We work hard on sign conventions. It is of prime importance that students should understand the computer output and be able to assess the results critically. Is the quadrant of the phase shift correct? If not, is the input wrong or is the program faulty? Much time is devoted to techniques that aid in understanding and permit rough estimates. These are not tools for calculation but tools for understanding. Improved understanding increases student confidence. We believe that our most important achievement is the instilling of a justifiable feeling of confidence.

Students can take only so much in the way of lectures each day. We therefore break the day into four periods of roughly equal length, two in the morning and two in the afternoon. The first part of morning and afternoon is formal lecturing with all the interaction we can encourage. The second parts of morning and afternoon are practical work on a computer applying the lessons of the lectures. Here we insist on one student to each computer. We have found computer sharing to be completely counterproductive. This is a time when individual interaction between instructor and student can take place. There is also a degree of networking between the students themselves and we also encourage this. Sometimes students will use these tutorial computing sessions to ask advice about their own specific problems. If their employer permits we encourage them to bring current problems with them so that we can discuss them. Thin Film Center develops commercial software packages and it is this software that we use in these tutorial sessions. But this is not in any way a selling exercise. The software is purely a reinforcement tool that works very well.

There is no test associated with the course. Every student who attends is given a certificate. To boost confidence further, we emphasize to each student that we are always available to answer any questions connected with the course that might arise later. The courses appear very successful and many attend through recommendations by earlier students. Some organizations use our courses as part of their training program for new employees.

The talk will include examples of some of the techniques, with general observations concerning student capabilities and reactions, and on continuing education in general.