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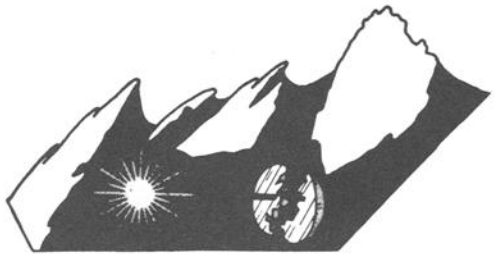
Laser Induced Damage in Optical Materials: 1986



BOULDER DAMAGE SYMPOSIUM

ASTM

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Laser Induced Damage in Optical Materials: 1986

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BOULDER DAMAGE SYMPOSIUM

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Foreword

The Proceedings contain the papers presented at the Eighteenth Symposium on Optical Materials for High Power Lasers held at the National Bureau of Standards in Boulder, Colorado, on November 3-5, 1986. The Symposium was jointly sponsored by the National Bureau of Standards, the American Society for Testing and Materials, the Office of Naval Research, the Defense Advanced Research Projects Agency, the Department of Energy, and the Air Force Office of Scientific Research. The Symposium was attended by almost 200 scientists from the United States, the United Kingdom, Japan, France, and the Federal Republic of Germany. It was divided into sessions devoted to the following topics: Materials and Measurements, Mirrors and Surfaces, Thin Films, and finally Fundamental Mechanisms. The Symposium Co-Chairmen were Dr. Harold E. Bennett of the Naval Weapons Center, Dr. Arthur H. Guenther of the Air Force Weapons Laboratory, Dr. David Milam of the Lawrence Livermore National Laboratory, and Dr. Brian E. Newnam of the Los Alamos National Laboratory. They also served as editors of this report.

The editors assume full responsibility for the summary, conclusions, and recommendations contained in the report, and for the summaries of discussion found at the end of each paper. The manuscripts of the papers presented at the Symposium have been prepared by the designated authors, and questions pertaining to their content should be addressed to those authors. The interested reader is referred to the bibliography at the end of the summary article for general references to the literature of laser damage studies. The Nineteenth Annual Symposium on this topic will be held in Boulder, Colorado, October 26-28, 1987. A concerted effort will be made to ensure closer liaison between the practitioners of high peak power and the high average power community.

The principal topics to be considered as contributed papers in 1987 do not differ drastically from those enumerated above. We expect to hear more about improved scaling relations as a function of pulse duration, area, and wavelength, and to see a continuing transfer of information from research activities to industrial practice. New sources at shorter wavelengths continue to be developed, and a corresponding shift in emphasis to short wavelength and repetitively pulsed damage problems is anticipated. Fabrication and test procedures will continue to be developed, particularly in the diamond-turned optics and thin film areas.

The purpose of these symposia is to exchange information about optical materials for high power lasers. The editors will welcome comment and criticism from all interested readers relevant to this purpose, and particularly relative to our plans for the Nineteenth Annual Symposium.

H. E. Bennett, A. H. Guenther,
D. Milam, and B. E. Newnam
Co-Chairmen

Disclaimer

Certain papers contributed to this publication have been prepared by non-NBS authors. These papers have not been reviewed or edited by NBS; therefore, the National Bureau of Standards accepts no responsibility for their accuracy, nor for their comments or recommendations.

Certain commercial equipment, instruments, and materials are identified in this publication in order to explain the experimental procedure adequately. Such identification in no way implies approval, recommendation, or endorsement by the National Bureau of Standards, nor does it imply that the equipment, instruments, or materials identified are necessarily the best available for the purpose.

CONTENTS

Thin Films

Surfaces and Mirrors

Fundamental Mechanisms

WELCOME TO THE EIGHTEENTH ANNUAL SYMPOSIUM ON OPTICAL MATERIALS FOR HIGH POWER LASERS

Arthur H. Guenther
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On behalf of my three co-chairmen, Hal Bennett, Dave Milam and Brian Newnam, we would like to welcome you to this, the eighteenth in this continuing series of symposia. Unfortunately, Hal Bennett is not able to be with us this year. He was here until yesterday, but he had to appear in court to settle some legal matters in California and he wishes to express his regrets that he is not going to be present. He'll be here in spirit certainly. As you just heard from Dr. Kamper, we are welcome back next year. I'm sure Hal will be with us at that time.

As the first viewgraph shows, the conference continues its steady growth. Last year we had 67 papers and about 225 attendees. This year we have 75 papers and I don't know what we will have in attendance but the 145 or so pre-registered was the largest number so recorded through any of these meetings, and there were at least another 40 to 50 who signed in last night.

I think it is important to note that the symposium continues to reflect the recent interest in thin films at this particular meeting. This year there are still twice as many papers in that category as in any of the others that we normally separate our papers into: materials and measurements, surfaces and mirrors, and fundamental mechanisms. In fact, we have moved thin films up in the sequence to follow materials and measurements since it encompasses a very large part of the meeting.

We hope that the proceedings from the 1984 meeting will be available for you to pick up tomorrow afternoon if the printing office delivers as promised. (They were.) This meeting has been the most dynamic in scheduling and I would ask that each of you please check your program and the short, late-change sheet to ensure that you know where we are and that if you have a paper, you know where it occurs. If you can't find it, please let us know right away. We do have a couple of slots open because we have had some extra poster boards made and one cancellation has given us an additional oral position.

The '85 proceedings are progressing but at last count there are 16 manuscripts that have not been received. Some wanted me to read the delinquent authors' names and ask them to stand up so that you could look and see who they were, but even I didn't want to start off the meeting in that manner. Rather, I would like to ask those of you

who are here who have manuscripts that are still among the missing, they are listed on the bulletin board outside, to please check off the status and give an indication when we might expect them. I will say we are progressing very rapidly to sending the proceedings to the publisher. In fact, three manuscripts were delivered this morning from last year's meeting, so they made it within a year, but we do have 16 that are still delinquent.

This is an opportunity to say a few words to you on a subject I think is most important. Without a doubt, these symposium proceedings, in my opinion, form the best and most comprehensive chronology of power optics problems and solutions from 1969 on. I think they continue to form the framework of the most significant work in the field. They have led not only to an efficiency in our progress in advancing optical materials for high power lasers but a recognition and recording of previous work resulting in avoidance of duplication. In fact, they have formed the basis of a tutorial in an educational sense for others entering or working in the field. I can't emphasize enough the investment we've all made and the need to continue to document results as we solve problems and proceed to new areas. In fact, the very format of this meeting, to wit, no parallel sessions, lots of discussion opportunities, and unlimited documentation, has engendered the technical world a cadre of mature well-informed specialists who are frequently called upon to overcome a major constraint in laser development, applications, or to improve designs.

Let me now add a few words about the state of affairs concerning the topics of today's interests as relates to this meeting. We continue to see new materials coming on the scene, primarily driven by applications such as short wavelength operation. For example, there is a lot of attention being given in the transparent case to calcium fluoride and some to lithium fluoride or metallics or inter-metallics in the case of substrates or reflectors both at short wavelengths and in the infrared. Just as applicable, however, I don't know why polymers have not really caught on more and it is unfortunate that we just heard last week that Professor Manenkov will not be with us to share his latest results in this field. Certainly polymers is an area that has caught on quite heavily in the Soviet Union. On the other hand, we do continue to see continued improvements and opportunities in sol-gel and related material technologies.

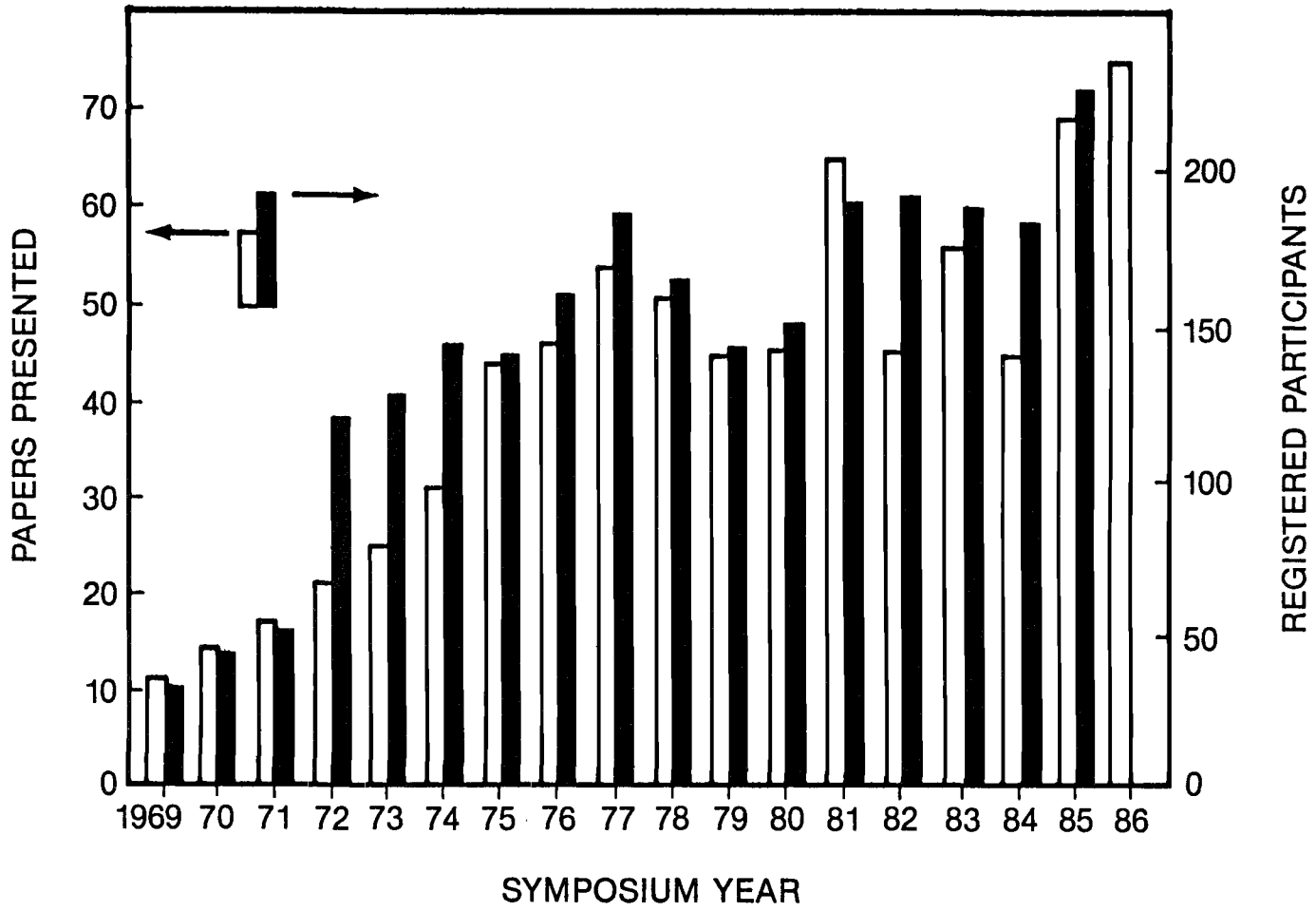
However, as I indicated, coatings still dominate the meeting and there is no question as to why that is; there is considerable leverage because of the multitude of applications. There is, as well, an inherent belief that there is a lot of room for improvement. The focus this year comes in several categories. First, and perhaps foremost, is the attention that is being given to the issue of thermal conductivity in thin films. Thermal conductivity is a very structure-dependent property of the material. This quality has a great impact upon the modeling that we have heard so much about in the last few years. In the past, if people used the thermal conductivity of bulk material, to come up with an estimate to compare with experimental measurements of

damaged threshold, they had to evoke an extremely high and fictitious absorption level, too high in fact to be credible. People were starting to look for other explanations to explain the high absorption levels. Recent reports of thermal conductivity measurements, where we see decreases ranging from 50 to 500, and in some cases maybe even to 1000, greatly alleviates this apparent inconsistency in that it limits the amount of heat that can be conducted away from an absorbing site. This in fact will, I am sure, bring better agreement between the modeling estimates and the quality experimental measurements of the damage threshold that we obtain in the laboratory.

Another area that has received a lot of attention is certainly the application driven area. Free-electron lasers certainly come to mind immediately. Brian Newnam pointed out a few years ago that there is going to be a problem with high fluences and there's going to be a problem with the diverse duty cycles of rf and inductive driven accelerators; which give you entirely different pulse train considerations. Add to this the wavelength agility which others see as an advantage in FELs. It becomes nothing but a problem for the people who wish to design FELs to have all the advances that they inherently offer.

We do see continued advances in instrumentation, and you will hear some interesting papers this year on spectroscopic ellipsometry. There has been a lot of attention given to this work over the last two or three years at the Naval Weapons Center, at Bell Laboratories, and at the Materials Research Laboratory at Penn State. It appears now that this technique is starting to give us some information about the structure inside films and as was pointed out earlier this year by Hal Bennett and others, one can actually determine surface roughness by this technique. There has been excellent agreement between that predicted from the ellipsometric measurements and that determined from surface profilometry. But, of course, on the same issue of instrumentation, we still are seeking that illusive and what we hope eventually to be a widely accepted facile pre-catastrophic damage indicator. It still seems that a lot of people are working on the issue of desorption as one possible solution to their problem, and there are several papers on that subject at the meeting today. Finally, from the instrumentation standpoint, it is gratifying to note the increase in the automated damage testing facilities throughout the world and I think this can only help advance coating technologies in allowing more rapid and economical assessment of perhaps the last active coating area, and that is process improvement. Which is leading in its own way to better coatings, and I mean better in terms of the eventual application, which may not be the one that you went out to solve.

There is no question that the hallmark of this meeting has been its flexibility to go where the action is and to consider and conquer new problems in both a systematic and synergistic manner.


PAPERS PRESENTED
REGISTERED PARTICIPANTS
SYMPOSIUM YEAR
0
10
20
30
40
50
60
70
0
50
100
150
200
1969
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86

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