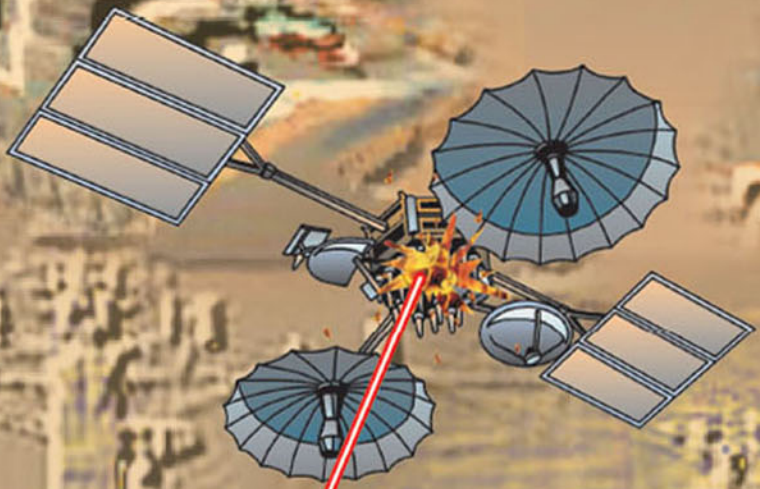
PHOTONICS IN WARFARE



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DEFENCE SCIENTIFIC INFORMATION & DOCUMENTATION CENTRE
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MINISTRY OF DEFENCE, INDIA

PHOTONICS IN WARFARE

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Defence Research & Development Organisation
Ministry of Defence
New Delhi – 110 011
2002

Light

from the sun sustains life,
from feeble flame fights dark and dispels fear,
(is the object of concentration for many)
On reflection informs and adds to knowledge,
(lack of it casts shadows and doubts)
In cosmic garb it is the very Existence;
but as weapon of war
it carries death and destruction.

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Photonics in Warfare

VV Rampal

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PREFACE

The last quarter of the twentieth century has been particularly significant for the growth and maturity of photonics. It has seen the development of lasers and fibre optics resulting in a vast area of application both in civil and defence sectors. It made some optimists to declare that future belongs to photonics. To some extent it has come true. We are now living in an age dominated by optoelectronics and computers. Though application of lasers in Defence have been written about and emphasised time and again, an overall view of the role of photonics in warfare technology needed to be discussed in a single volume for the R & D scientists and managers. The book attempts to do just that. The literature is scattered and at time scarce due to security considerations. However, trends of developments are visible and an attempt can be made for forecasting the level of intrusion that photonics is likely to make in the defence instrumentation and weapons of tomorrow.

Chapter 2 to 8 emphasise the technology status in the last decade, in particular reference to optical or optoelectronic devices and systems used in modern warfare. Based on this information and the impact of emerging technologies of integrated optics and microoptoelectronic structures, an attempt is made to peep into the future directions of micro miniaturization and intelligent systems. It is easy to conclude that photonics does indeed have a future in warfare technology of tomorrow. The systems are likely to be more robust, more reliable, smaller in size and intelligent enough to take decisions without human intervention.

I wish to put on record the contribution of Dr. A Selvarajan in writing part of Chapter 2. I would have liked more from him, if circumstances had permitted to do that. I also wish to acknowledge all the help extended by DESIDOC in bringing the book into the present form. I am thankful to DRDO for providing the necessary

financial support, and to the Directors of some DRDO laboratories (e.g., DESIDOC, Delhi; DEAL, Dehradun; DLRL, Hyderabad; ARDE Pune; and ADE, Bangalore) for allowing the use of libraries and technical information centres for scan of research publications.

I sincerely wish and hope this monograph brings the necessary awareness about the role and importance of photonics in warfare technology and encourages the development of photonics based instrumentation in defence preparedness in the years to come.

Dehradun
April 2002

VV Rampal

CHAPTER 1

INTRODUCTION

Photonics has been truly described as the technology of future. Its increasing relevance in diverse fields has made it to emerge as a field of promise. It provides a hope to reach the frontiers not yet achieved, particularly in areas bordering science fiction, such as killer beams and optical computation.

Conventionally, photons are related to the optical region of spectrum. As such, photonics deals with light and, in some cases, with near infrared region. But over the years, rapid advancements in the field of optics and electronics have blurred the classical definitions of various related phenomena; thereby leading to the use of terms like electro-optics & opto-electronics rather interchangeably, even though conservatives would still like to use the terms with great caution. There is however, general agreement that the term photonics should embrace all the activities connected with generation and manipulation of photon stream either by optical means or by electrical methods or by both. This provides a generic nomenclature for all techniques, which employ electro-optical or opto-electronic components and devices for performing a particular function.

Like any emerging field, photonics also promises applications, which are only limited by the imagination of the users. In some areas, it not only supplements but even surpasses the expectations from existing techniques. There is already a vast body of literature existing, which provides optical/electro-optical methods for achieving desired objectives in scientific, industrial, medical and commercial sectors. But that is not our objective in this volume. The present monograph attempts to highlight the principles and uses in another, rather obscure area of warfare technology where

photonics is increasingly becoming relevant. The emerging confidence in laser weapons, and consequently the need for countermeasures, is an obvious example.

The ability to strike military targets, while minimising the risk of damage to civilians and urban infrastructure, has proved to be an important policy option for military planners and political decision makers. Electro-optic targeting systems have already provided the ability to attack hostile elements deliberately placed close to or within urban areas and civilian population centres. These are important considerations for modern forces. Offensive actions need to be carried out with minimum risk to own forces and civilian infrastructure. In modern military systems, it is photonics that provides the option.

Another benefit of photonic systems arises from the comparatively short wavelengths that they use (~1 to 10 μ). The spatial resolution of an electro-optical system and a radar are governed by the same laws – the aperture (antenna) must be large compared to the wavelength, if a narrow transmitter beam or a finely detailed return is needed. For similar resolution, a radar needs an aperture (real or synthetic) that is hundreds to thousands times larger than an electro-optical system. Further, unlike radars, electro-optic systems can operate passively, thereby reducing the risks of detection and counterfire. This is because the photonic systems can exploit the illumination provided by the sun, moon, stars, or even airglow and all objects radiate thermal energy in proportion to their temperature.

In a wider context, photonics can be described as the technology of generating and harnessing light and other forms of radiant energy whose quantum unit is the photon. It is concerned with the study and uses of lasers, electro-optics, fibre optics, and both classical and quantum optics. One may also view it as a branch of science in which photons play the same role as electrons do in electronics. It is thus, related to the functions connected with the manipulation of photon beams in respect of its energy density in different media and the control it provides to other functions.

1.1 PHOTONICS AND ELECTRONICS

Electronics and optics correlate to the properties of electrons and photons. The two particles have some basic differences

About the Book

Photonics has assumed an important place in the military hardware and one can look forward to ever increasing applications in future. Over the years, high power lasers have tremendously increased the potential of optical radiation for weapon systems. The challenges and opportunities provided by photonic technology in future wars cannot be overlooked. This book presents an integrated view of the present and potential applications of optical radiation including infrared in a war scenario. It is intended to serve as a treatise on the development of photonics-based weapons and instrumentation. In addition to summarising the efforts of the last thirty years, suggestions for countermeasures and future trends have also been included. The book provides reference information relevant to scientific laboratories, training institutions and other organisations connected with development and use of weapons in war.

About the Author

VV Rampal received his PhD in tunable lasers from the University of Southampton, UK, as a Commonwealth scholar. He has taught at the University of Roorkee and Indian Institute of Technology, Kanpur and has over thirty years experience of working in the R&D of photonics and lasers applied to Defence Instrumentation. As a senior scientist at DRDO laboratories at Dehradun, he worked in the development of laser-based instrumentation, experimental nonlinear optics and electronic imaging. He has also served as Adviser in the Ministry of Science and Technology, Govt of India. His publications, over a hundred including three books, cover the area of lasers and opto-electronics, fibre optics and nonlinear optics. He is a founder member of the Indian Laser Association

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