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About the Editor

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Preface

The use of laser science and technology in materials development has made significant progress thanks to the flexibility of beam/surface interaction with regard to wavelength, energy-density and interaction time; together with interaction environment. It is difficult to think of any field of science where lasers have not made their mark in improving properties and characteristics or in broadening applications. Lasers have not failed to advance medical science or even defence applications. In the present volume, experts in the relevant fields attempt to cover just some of the multitudinous aspects of laser techniques.

In the first chapter, various types of laser-driven reaction are discussed in a phenomenological way, for cases ranging from purely thermal reaction to bond-specific chemistry. The authors present an overview, at different time-scales, of intramolecular processes and of the resultant possibilities for bond- or mode-selective chemistry. This is followed by a chapter in which the laser-induced fluorescence (LIF) technique is applied to kinetic studies of gas-phase free-radical reactions which are relevant to the atmosphere. The atmospheric chemistry of these radicals, and the principles of reaction-rate measurements, are described and the LIF characteristics of the radicals are reviewed.

In chapter three, intrinsic and extrinsic interaction mechanisms of laser radiation with materials are briefly described. Phase transformations in metals and semiconductors, as promoted by excimer laser irradiation, have extended the understanding of these phenomena from near-equilibrium to very far-from-equilibrium conditions. It is further shown that the changes produced in the near-surface regions of materials, by pulsed laser irradiation, are a fertile ground for the development of new laser-based techniques for material processing. Some examples are given. In chapter four, the fundamental problems which are encountered in the application of laser spectroscopic imaging to imaging diagnostics are considered. The imaging of the pulsed laser deposition of high-T_c superconducting thin films and silicon nano-particle synthesis are described. In the next chapter, the advantages of visible (800nm) ultra-short laser pulses for the microstructuring of high band-gap materials are considered. Some interesting effects which are observed while using ultra-short laser pulses to process dielectric materials are described. Many of the observed effects can be understood, at least quantitatively, in terms of the mechanisms of the initial electronic excitation and dynamics of ensuing defect production and decay.

The sixth chapter compares the processes involved in ion/surface and laser/surface interactions: ballistic, thermal spikes, residual defect-induced and electronic. It is shown that ballistic processes are important for ion-sputtering, ion-mixing and ion composition changes and that, although they occur during laser-pulse sputtering, they are not important there. The situation with regard to thermal spike processes is just the reverse: in laser-pulse sputtering, a distinction has to be drawn between normal vaporization and phase explosion. Sputtering due to sub-surface heating, although commonly advanced, does not exist. The primary laser/surface interactions are predominantly electronic, but most of the deposited energy is rapidly converted from excitation to heat and it is for this reason that thermal spike sputtering is so prominent. It is further considered that laser sputtering has two aspects; involving primary processes which lead to particle expulsion, and secondary processes which arise due to collisions between the emitted particles. In the seventh chapter, the authors show theoretically that the temperature rise which is caused by the laser beam governs the processing rate, reaction features, surface morphology and processing-induced surface defects. Modelling of the temperature distributions induced by lasers is presented, from a theoretical point of view, for the case of anisotropic media or those exhibiting a complicated temperature dependence of the thermal conductivity. Laser-induced temperature distributions in substrates with periodic multi-layer structures are derived, and control of the substrate temperature distribution via Gaussian-shaped or multiple-beam irradiation, are described.

In the eighth chapter, laser alloying and cladding are considered with regard to the synthesis of novel materials and surface treatments. It is noted that there is an increasing industrial interest, in laser-cladding, in areas as diverse as the automobile, aerospace and processing industries. In the ninth chapter, the latest designs of CO_2, Nd-YAG and diode lasers for industrial application are reviewed. The relevance of beam quality is demonstrated, and the advantages and problems of various designs are discussed.

The final chapter considers the role of laser radiation as a tool for generating well-defined thin-film properties for applications involving ceramic materials.

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