

# Preface

Thermoluminescence (TL) is a well-established technique widely used in dosimetric and dating applications.

Although several excellent reference books exist which document both the theoretical and experimental aspects of TL, there is a general lack of books that deal with specific numerical and practical aspects of analyzing TL data. Many times the practical details of analyzing numerical TL glow curves and of applying theoretical models are difficult to find in the published literature.

The purpose of this book is to provide a practical guide for both established researchers and for new graduate students entering the field of TL and is intended to be used in conjunction with and as a practical supplement of standard textbooks in the field.

Chapter 1 lays the mathematical groundwork for subsequent chapters by presenting the fundamental mathematical expressions most commonly used for analyzing experimental TL data.

Chapter 2 presents comprehensive examples of TL data analysis for glow curves following first-, second-, and general-order kinetics. Detailed analysis of numerical data is presented by using a variety of methods found in the TL literature, with particular emphasis in the practical aspects and pitfalls that researchers may encounter. Special emphasis is placed on the need to use several different methods to analyze the same TL data, as well as on the necessity to analyze glow curves obtained under different experimental conditions. Unfortunately, the literature contains many published papers that claim a specific kinetic order for a TL peak in a dosimetric material, based only on a peak shape analysis. It is hoped that the detailed examples provided in Chapter 2 will encourage more comprehensive studies of TL properties of materials, based on the simultaneous use of several different methods of analysis.

Although the subject of TL curve fitting and glow curve deconvolution is beyond the scope of this book, the readers may find the spreadsheet examples in Chapter 2 useful and easily adaptable for implementing simple curve fitting algorithms. These algorithms are based on the experimentally measurable maximum TL peak height and the corresponding temperature ( $I_M$  and  $T_M$ ). In the examples given, the activation energy  $E$  acts as the adjustable parameter in the computerized curve

fitting procedure. Several of these curve fitting spreadsheet examples can also be found in the authors' website.

Chapter 3 presents for the first time in the TL literature detailed numerical examples of several commonly used theoretical models, as well as several comparative studies of analytical expressions used for kinetic analysis of TL data. The main thrust of this chapter is to illustrate how to solve the differential equations describing the traffic of carriers during the various TL processes in the crystal. A few simple examples of solving the basic differential equations of TL using a spreadsheet are given mostly for illustrative and educational purposes. The main body of this chapter consists of a gradual presentation of increasingly complex TL models using the program *Mathematica*.

We have found this programming environment to be very efficient, versatile, and easy to work with, once the basic structure and programming style have been mastered. We emphasize in particular the transparent nature of the numerical integrating techniques used in *Mathematica*, which are particularly suited for solving systems of "stiff" differential equations that are common in theoretical TL work. The *Mathematica* numerical integration code is very stable and efficient, with rare occasional numerical instabilities. All examples given in this book have typical running times of 1–2 min on a desktop computer. Several of the *Mathematica* examples given in this book can also be found in the authors' website for easy reference and download.

In Chapter 4, we give numerical exercises relevant to the TL dose response of dosimetric materials. The models described in this chapter are taken directly from the published TL literature in order to facilitate direct comparison of the results with the original papers. As much as possible, we have kept the same symbols and mathematical notation as the original papers for easy cross-reference. The *Mathematica* programs are given in a "modular" form consisting of a small core of subroutines performing separate tasks, which can be easily adopted by the readers for a variety of different purposes.

A very important class of TL models is presented, namely models based on competition during irradiation process, competition during the TL heating process, as well as models containing competition during both irradiation and heating. The last exercise in Chapter 4 presents a numerical example of how the superlinearity and supralinearity coefficients  $g(D)$  and  $f(D)$  can be calculated from experimental TL versus dose curves.

In Chapter 5, we present a variety of exercises dealing with practical aspects of several phenomena commonly encountered in the study of TL materials. A group of four numerical exercises deal with the accuracy and reproducibility of measurements performed using TL dosimeters (TLDs). In particular, we show how the statistical accuracy and reproducibility of TL data can be greatly improved by using individual correction factors for each TLD. The next two exercises deal with the commonly observed phenomenon of thermal quenching and comprise a detailed simulation of thermal quenching effects on the measured TL glow curves and on the initial rise technique. The next group of two exercises deals with aspects of the mathematical formalism used in environmental TL dosimetry.

Two extensive exercises in Chapter 5 concern with the important but somehow underutilized technique of the TL-like presentation of phosphorescence decay curves and with the practical aspects of how to correct experimental TL data for temperature lag effects between the heating element in TL equipment and the sample itself.

Astute readers will notice the absence from this book of any exercises dealing with dating applications of TL. We decided that such exercises were beyond the specific scope of this book and refer the readers to the review papers in the annotated bibliography, as well as to the monographs dedicated to this important topic.

Perhaps, one of the most useful aspects of this book is the inclusion of an annotated bibliography on TL topics. To the best of our knowledge, there has been no other published annotated bibliography in the TL literature, and we believe that this will be an important tool for both established TL researchers and persons starting a research project in this field.

Although it is not possible to give a comprehensive annotated bibliography, we have provided characteristic examples of published articles in the various topics covered in this book. Several review articles of general interest on TL have also been included in our listings; these can serve as important introductory material for the various topics.

Our choices of papers and monographs in the annotated bibliography were dictated by our desire to guide the reader toward few characteristic and complete examples of TL data analysis, rather than providing a complete list.

An Appendix is provided with examples of the most basic commands in *Mathematica* for reference purposes, although it can only cover the most rudimentary aspects of this powerful programming environment.

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