A finite element model of phase-change recording

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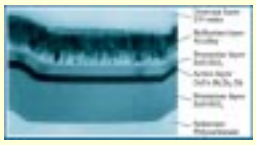
Introduction

Optical rewritable disks consist of various layers. Data can be stored using a high power laser that is focused on the active phase-change (PC) layer to create amorphous marks in the crystalline background. Written marks can be erased by applying the same spot at a lower power level. The modeling of the process of PC-recording can be subdivided into three parts:

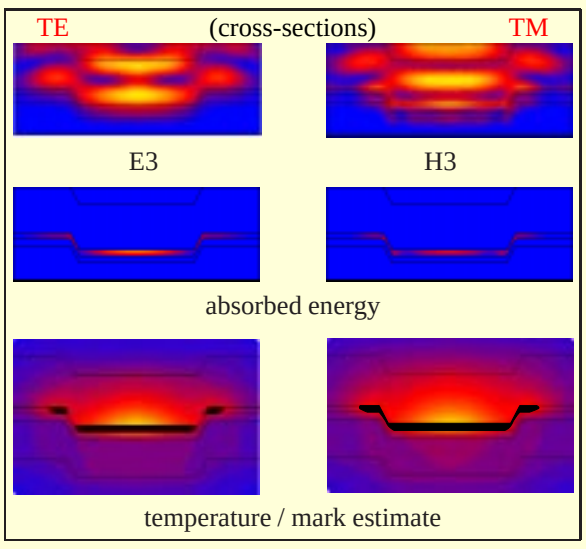
- Computation of the absorbed light,
- Calculation of the temperature distribution,
- Modeling of mark formation and erasure.

The aim of this project is to develop a finite element model that incorporates all three subprocesses.



A coupled optical/thermal model

A rigorous finite element model for the scattering of a 3D-focused spot by a 1D-periodic grating has been developed to compute the absorbed electro-magnetic density in a 3D region of interest in the disk. We have combined this optical model with a thermal model to compute the temperature distribution in the disk. Here, it is assumed that all absorbed energy induces the rise of temperature. Thus, the latent heat for melting has not been taken into account. By assuming that the region in which temperatures have risen above the melting temperature has become amorphous, the shape and size of the mark can been estimated.



Modeling the writing of a mark

Two steps can be distinguished in the writing process of a mark:

- Melting of the PC-material during the laser pulse
- Solidification/amorphization

Both melting and solidification can be modeled by means of an enthalpy formulation. Latent heat, which is the amount of energy required for the solid-to-liquid transition, is included in a natural way. An enthalpy or level set method, based on FEM, is being considered as a numerical solution method.

growth dominated nucleation dominated

Modeling the mark erasure

At temperatures between the glass temperature and the melting temperature of the PC-material, recrystallization of the amorphous regions occurs, and data can be erased. The crystallization can be nucleation dominated or growth dominated. Nucleation is a statistical process, whereas growth can again be modeled as a moving boundary problem.