Phase-change Media of Optical Recording: Physical Properties, Characterization Methods, and High-end Applications

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Abstract: We discuss some important characteristics of phase-change materials used in high-density, high-speed, rewritable optical memories. Methods of optical and thermal characterization of these media will be described, and their behavior under single as well as multiple sub-nanosecond laser pulses will be examined.

Keywords: Optical recording, Phase-change media, Thin-film characterization techniques.

With the increasing demand for high-capacity, high-data-rate optical disks, the need for better tools/techniques to evaluate the storage media has been on the rise. We have developed a two-laser media tester to investigate the recording dynamics in phase-change (PC), magneto-optical (MO), and dye-polymer disks as well as in other media samples. The system diagram in Fig.1 shows two laser beams for read and write operations (λ_R = 422nm, λ_W = 398nm) coincidentally focused on the sample through a μ-scope objective (NA= 0.6). The reflected beams are separated and monitored for changes in sample's reflectivity or magnetization state. Typically, one laser is pulsed (duration τ_W, power P_W) to record a mark on the sample, while the other is used at low power in cw mode (power P_R) to monitor the changing local properties. The inset in Fig.1 shows a photograph of crystalline marks (~1-2 μm) recorded on an amorphous thin-film sample using different pulse powers/durations. Similar marks can be recorded on MO films with the aid of an electromagnet.

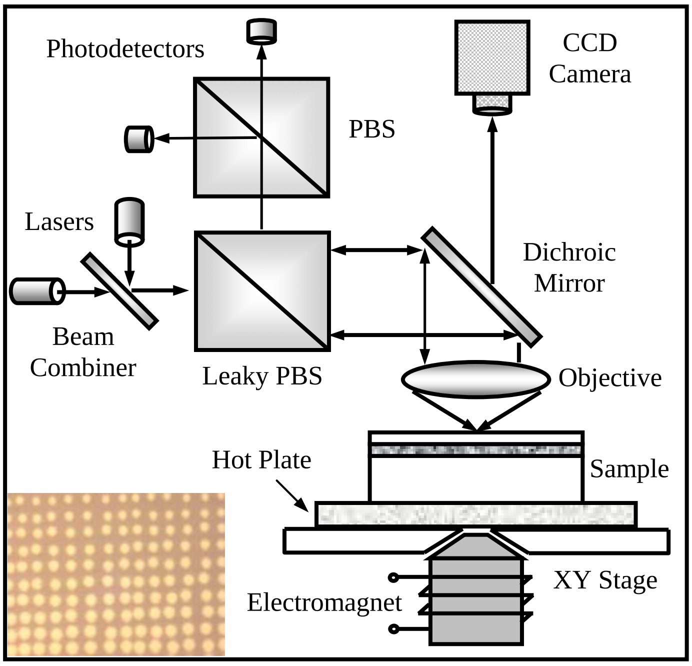

Fig.1. Diagram of the measurement system. Beams from two lasers of differing wavelengths are combined and focused on the active layer of the sample; reflected beams are monitored in real time by fast photodiodes. The sample stage can be translated in small steps.

Figure 2 shows traces of reflectivity versus time for an 85 nm-thick film of the PC material InSnSb coated with a 60 nm-thick layer of SiO_xN_y. The initial rise in reflectivity upon application of a write pulse is due to local crystallization (followed by partial melting). The 100-150 ns delay between the end of the laser pulse and the final (sharp) increase in reflectivity may indicate a period of time in which the molten pool of InSnSb undergoes super-cooling before it rapidly crystallizes at the end. At larger values of P_W the molten pool is larger and so is the recorded crystalline mark, hence the larger reflectivity attained at the end of the process.

We have used these and many similar measurements (obtained on samples of differing structure at elevated ambient temperature, with pulse durations ranging from a few nanoseconds up to several milliseconds) to elucidate the behavior of writable and rewritable media of optical data storage. In addition to gaining insight into the dynamics of crystallization, melting, melt-quenched amorphization (PC media), as well as magnetization reversal (MO media), we have used these techniques to extract information about thermal constants of the active layer as well as the encapsulating dielectric and metal layers used in commercial optical disks.

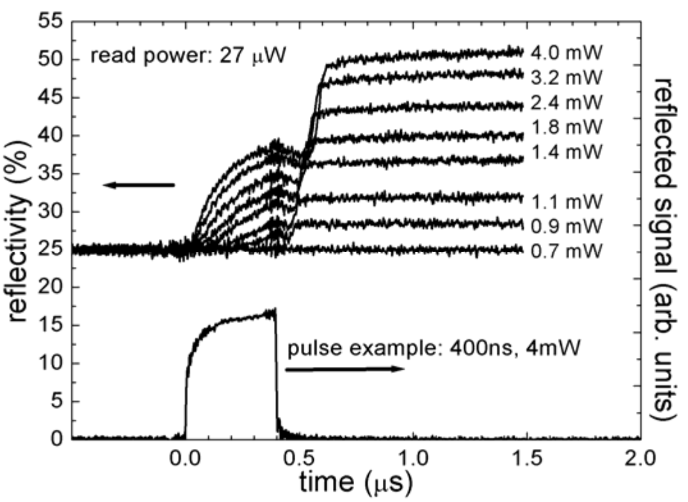

Fig.2. Reflectivity versus time as measured before, during, and after a τ_W = 0.4 μs pulse of varying power P_W. From top to bottom, the traces correspond to P_W = 4.0, 3.2, 2.4, 1.8, 1.4, 1.1, 0.9, and 0.7mW, respectively. The CW read power is fixed at P_R = 27μW.