Preface

Optical disc industry is one of the successful businesses in the world, and huge amounts of discs and drives have been spread all over the world. More than a billion discs are produced and distributed every year. Since the first optical discs – Laser Discs and Compact Discs (CD) – were shipped in the early 1980s, they have rapidly dominated the world music market, and DVDs will replace the video-tape market in the near future. The optical disc and drive technologies consist of the most advanced and integrated systems with regard to optics, physics, chemistry, mathematics, electronics, mechanics and related subjects; a huge number of scientists and engineers have engaged in the research and development of the systems. One of the key factors of the development of the optical disc systems, of course, results in the availability of cheap, stable, and reliable semiconductor laser units. Now, you can store data up to 4.7 GB on a single side of the 12-cm DVD, and in the near future, blue laser technology will allow storage of more than 20 GB on the same size disc. We should not however forget the other core technologies such as focusing the beam on the surface of a spinning disc precisely, and encoding and decoding digital data. The data capacity of optical discs has increased from 0.65 GB to 25 GB by the year 2003, and we certainly believe it will continue to increase with new technologies. Although the principle of optical recording and readout depends mostly on optics, the technology is now closing to the theoretical limit of the capacity. Focusing a laser beam into a small spot with a diameter as small as 1 µm by the combination of several lenses, the readout head can detect and separate two different marks that are about half the spot size. In a CD, the spot size is 1.0 µm and the minimum mark size is 0.8 µm as determined by a red laser (780-nm wavelength). In a DVD, on the other hand, the spot size is focused by 0.6 µm, and the mark size is approximately 0.4 µm. In a next generation DVD using a blue laser, the spot is further squeezed by 0.3 µm around and the minimum mark is less than 0.2 µm. The available technologies so far depend on the development of new shorter-wavelength semiconductor lasers and sophisticated lenses, also known as "far-field optics." They are, however, closing in on the limit of the resolution due to the diffraction limit.

This book *Science and Technology for Optical Near-Field Recording* discusses the introduction of advanced science and technology to overcome the resolution limit with the help of new technology called "near-field optics."

The optical near-field is a special electromagnetic field that cannot propagate a long distance (unlike optical waves), but trapped very close to an object surface. Such non-propagating field has sometimes been called surface plasmon polaritons or simply surface plasmons. Their existence was discovered in the early 1900s, but its characteristics were not well understood. Their unique properties were not deeply examined until near-field scanning optical microscopes (NSOMs) were designed in the 1980s, thanks to the development of the scanning tunneling microscope (STM) and scanning atomic force microscope (AFM). First application of NSOM to optical recording was carried out in the early 1990s, when the potential for super-storage density was confirmed.

This text book first summarizes in brief several core technologies used in the current CD and DVD optical disc systems in Chap. 2, where the background of optical data storage, several techniques to increase storage densities, and the present limit of the resolution are described. In Chap. 3, the basic principle of optical near-field and surface plasmons, and several methods to generate the fields are explained theoretically and experimentally. Computer-simulated graphics may help your further studies. In Chap. 4, new approaches to realize super-density optical data storage with near-field optics are described. In particular, our discussion is focused on the flying-head system, a specially designed lens system called "solid immersion lens," and a thin-film technique called "Super-RENS." These three novel technologies have been proposed since the 1990s; the techniques are still amateur but the background science and technologies will provide many helpful new ideas in your future studies. In Chap. 5, the other applications of near-field optics and surface plasmons are introduced.

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Junji Tominaga
Takashi Nakano

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