

Laser system design for table-top X-ray light source

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Abstract

We present possible conceptual designs of a laser system for driving table-top free-electron lasers based on terahertz acceleration. After discussing the achievable performances of laser amplifiers with Yb:YAG at cryogenic and room temperature and Yb:YLF at cryogenic temperature, we present amplification modules with available results and concepts of amplifier chains based on these laser media. Their performances are discussed in light of the specifications for the tasks within the table-top light source. Technical and engineering challenges, such as cooling, control, synchronization and diagnostics, are outlined. These concepts for the laser layout feeding the accelerator are eventually derived and presented.

Keywords: concept; free-electron laser; lasers; optics

1. Introduction

Several laser facilities for strong-field physics experiments such as generation of attosecond pulses^[1], electron acceleration^[2], proton acceleration^[3, 4] or X-ray generation^[5], have been or are currently being built around the world. These facilities contribute to numerous advances in science, including physics, chemistry, biology, medicine and material science. Their development constantly faces technological and engineering challenges to reach the desired peak power, pulse energy, average power and lifetime.

The ‘table-top’ free-electron laser (FEL) powered by terahertz (THz) radiation proposed in the project ANSIS (Frontiers in attosecond X-ray science: imaging and spectroscopy) in 2016^[6] is part of the current intense research on alternative technologies to traditional, radio frequency (RF) based FELs^[7–8], which are very powerful but complex, large and expensive structures. These devices are thus few in number, resulting in very high demand and very limited access. The scientific community greatly benefits from alternative light sources with reduced size, cost and infrastructure needs. This demand has instigated extensive research efforts aiming

the realization of ‘table-top’ light sources^[9–12]. Nonetheless, all the proposed solutions, either directly or indirectly, take advantage from the recent progress in high-energy optical lasers, which are complex facilities.

Building an X-ray light source or other types of light sources entirely based on optical lasers requires a system capable of producing a multitude of diverse laser beams with various characteristics like center wavelength, spectrum, pulse duration and energy to serve as both drivers and diagnostic tools. In particular, for the ANSIS project, ultra-short ultraviolet (UV) pulses are required for electron generation, multiple beams of high-energy picosecond pulses are required for single-cycle THz generation and high-energy nanosecond (ns) pulses, with tailorable, tunable spectral and temporal profiles, are required for multi-cycle THz generation. In addition, the facility should run at high repetition rates with femtosecond level synchronization and stabilization. Such a system is highly complex and requires a combination of different laser technologies, some of which must be developed or customized. The right choice of technologies is crucial to its successful implementation and operation.

In this paper, we will first present the ANSIS project and derive the requirements of the driving laser system. Second, the available laser technologies will be reviewed. The third

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Selected Works of Professor Herbert Kroemer C. K. Maiti, 2008 Information technology has changed our society radically Just as the integrated circuits have been the prime mover for electronics high speed transistors and semiconductor lasers based on heterostructures are now playing the same role in modern telecommunications Professor Kroemer s conceptual work on heterostructures began in the early 1950s as he was looking for a way to improve transistor speed and performance In the 1960s he applied the same principles to the development of lasers and light emitting diodes showing that they could achieve continuous operation at room temperature OCo something thought impossible at that time His deep fundamental scientific work has had a profound effect on technology and society transforming and improving our lives This reprint collection brings together Professor Kroemer s most important papers presenting a comprehensive perspective of the field It covers topics ranging from substrate materials electronic properties process technology and devices to circuits and applications This reprint collection will help the reader identify the key stages in the development of heterostructure devices and lasers from early research through to its integration in current manufacturing Devoted to R D engineers and scientists who are actively involved in extending the nano and microelectronics roadmap mainly via heterostructure engineering this volume may also

serve as a reference for postgraduate and research students

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Advances In Information Storage Systems: Selected Papers From The International Conference On Micromechatronics For Information And Precision Equipment (Mipe '97) (Volumes 9 & 10) Bharat Bhushan, Kyosuke Ono, 1999-01-04 Advances in Information Storage Systems AISS volumes 9 10 are special volumes which contain selected papers regarding not only information storage but also information equipment in general and related technologies The papers were presented at the International Conference on Micromechatronics for Information and Precision Equipment MIPE 97 MIPE 97 was held in Tokyo Japan from 20 to 23 July 1997 as one of the memorial events of the Centennial Grand Congress of the Japan Society of Mechanical Engineers Information and precision equipment is fast changing high technology and is necessary for the development of an international multimedia society and essential for the innovation of conventional machines as well as the creation of new sophisticated machines for future medical biological and cosmic industries in the 21st century Information and precision equipment can improve their performances by analyzing designing fabricating controlling and then utilizing a smaller and smaller world in space and time Micromechatronics is not only a major interdisciplinary engineering but also the principle of innovation in such machines In the light of this the scope of MIPE 97 ranged from the micromechanics and micromechatronics of information storage input output devices and precision equipment to microtechnologies related to information equipment The papers in AISS special volumes are mainly related to information storage particularly magnetic recording storage But some of them are related to printer paper feeding mechanism and micromachine technologies which will directly or indirectly contribute future information devices The papers contained in this series are of international archival quality and are refereed according to rigorous journal standards Volume 9 contains papers on the mechanics and

tribology of magnetic recording storage systems mainly hard disk drives while papers on the micromechatronics of the head positioning system in magnetic disk storage are compiled in Volume 10 together with papers on optical disk storage and others

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