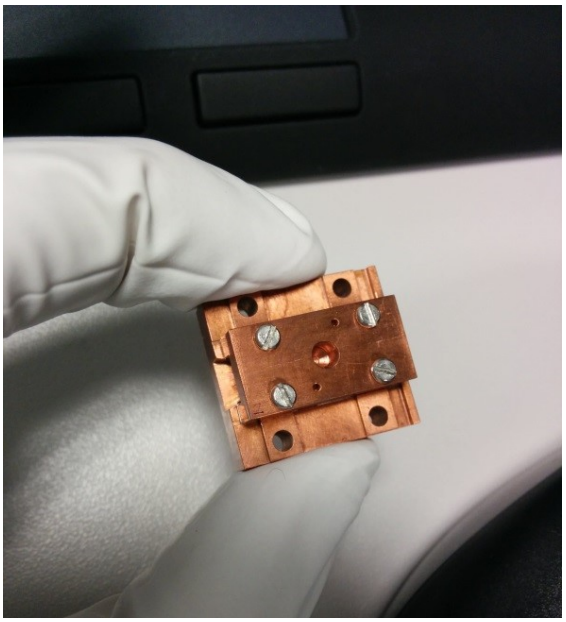
Laser based technologies

STEAM

Segmented THz Electron Accelerator and Manipulator



Key Facts

Advantages:
- Perfect synchronization
- Compact and low-cost device
- Ultrahigh fields

Development Status:
- Complete demonstration of the performance over multiple days of operation

Application:
- Electron beam diagnostics
- Electron beam manipulation
- Compact accelerators

Industrial Sector:
- Electron sources
- X-ray sources

Innovation

The invention concerns a segmented terahertz electron accelerator and manipulator (STEAM) device capable of performing multiple high-field operations on the six-dimensional phase space of ultrashort electron bunches. This single device, powered by few-micro joule, single-cycle, THz pulses, enables electron acceleration, deflection, streaking, compression and focusing as well as real-time switching between these operation modes.

This millimeter sized device can be easily integrated into big accelerator facilities to diagnose or manipulate the beam. In addition, it can be used to realize small and compact electron accelerators with improved cost and energy efficiency compared to conventional radiofrequency devices.

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DESY.

Applications Fields

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Challenges

Until recently, RF waves have been the conventional choice for powering accelerators due to the high degree of technical maturity of the sources. However, RF-based accelerators require costly infrastructures of large size and power, limiting the availability of this key scientific resource. They also suffer from inherent difficulties in synchronization with lasers, which lead to timing drifts on the 100 fs scale between the electrons, microwave drivers and optical probes, limiting the achievable temporal resolution. Strong motivation thus exists for exploring alternative technologies that are compact, more accessible and adapted for pushing the resolution frontier, especially where lower levels of charge in the few picocoulombs range or lower is sufficient.

Advantages

Owing to the terahertz operation bandwidth, the field strengths in the device can be increased by over an order of magnitude, far exceeding those of conventional radiofrequency devices. The exceptional performance and compactness of this terahertz-based device makes it very attractive for pursuing electron sources, such as ultrafast electron diffractometers, that operate in the few- and sub femtosecond range. In the pursuit of these sources, the demand is increasing for compact, high-gradient diagnostics and beam manipulation devices for novel and conventional accelerator platforms alike.

In large-scale facilities, such as the European X-ray free-electron laser (XFEL), the Linac Coherent Light Source (LCLS) or the Swiss free-electron laser (SwissFEL), the STEAM devices can be used to add new, powerful and adaptable capabilities without major and therefore costly restructuring of the machine. More significant are the advantages in terms of cost and accessibility that come from using STEAM devices as the core components of an all-terahertz-powered compact, high-gradient accelerator with the ability to produce high-quality, controllable bunches of femtosecond or attosecond duration on a table top.

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