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Next-Generation Laser-Driven Lightsources and Imaging Modalities for Nondestructive Evaluation (NDE) of the Energy Infrastructure

Abstract: The prosperity of our society critically depends on a reliable energy infrastructure. The continuous performance and resilience of the energy infrastructure can only be guaranteed by frequent and comprehensive evaluation of its components and detection of signs of degradation *before* problems occur. To provide uninterrupted operation, this requires non-destructive evaluation (NDE) of components often during operation. While many NDE methods for energy systems are well established, the transition from mainly nuclear- and carbon-based energy sources and transportation methods to new and likely more decentralized technologies will also require an unprecedentedly large and rapid shift to novel testing approaches1. This includes for example testing of new materials, manufacturing processes as well as challenges for NDE to identify new stressors, such as different degradation and aging phenomena1. It is expected that testing will have a major effect on the cost of the new energy systems as they are widely deployed.

The goal of this project is to investigate novel compact lightsources for NDE of energy-infrastructure relevant components and materials. The lightsource can generate ultrashort femtosecond (1fs=10-15 s) high-brilliance pulses in unconventional regions of the electromagnetic spectrum, where many materials are transparent. This includes long-wavelength terahertz (1THz=1012 Hz), hard X-ray and gamma-ray pulses. The source has a brilliance comparable to that of kilometer-sized synchrotron facilities but with table-top dimensions, which enables high-resolution imaging at a significantly reduced cost. Methods to optimize the source specifically for NDE will be investigated. From this it is expected that these sources to become even more compact and potentially fieldable in the future. Novel imaging modalities with the potential for higher resolution and lower cost compared to current technology will be investigated. With these, it is expected to perform NDE with few-micrometer resolution that would enable probing of micro cracks and voids in materials and compounds.