

First observation of high-harmonic generation in robust, refractory metals

13 September 2021, by Kristin Malavenda

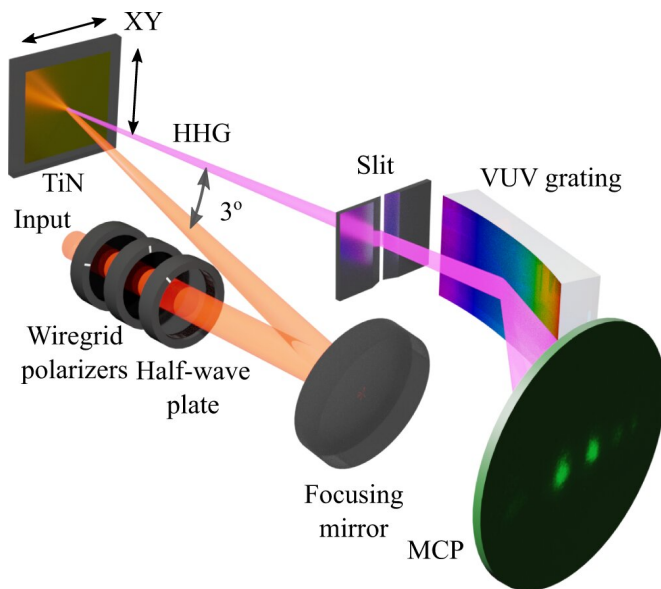


Fig. 1: Experimental setup. A 2.3-cycle laser pulse (central wavelength 770 nm) was passed through two wire grid polarizers and a half-wave plate. It was focused with a focusing mirror onto the TiN sample inside a vacuum chamber. The sample was mounted on a motorized XY stage, allowing its translation without realigning the optics. The generated high-harmonics radiation (HHG) passed through a slit, diffracted from a curved VUV grating, and reached the imaging microchannel plate (MCP) detector. The observed VUV spectrum was imaged with a CCD camera. Credit: DOI: 10.1038/s41467-021-25224-z

The generation of high harmonics from metals opens a link between solid and plasma harmonics. High-harmonic generation (HHG) is the field of creating high-frequency photons from low-frequency lasers. HHG is the cornerstone of nonlinear optics, with applications in spectroscopy, attosecond science and so on. In this study, researchers used titanium nitride to achieve HHG in refractory metals for the first time. In the future, this could pave the way to focusing the radiation down to nanoscale for use in nanomachining,

nanofabrication and medical applications, as well as HHG enhancement for the generation of frequency combs for the next generation of nuclear clocks.

Alexandra Boltasseva, the Ron and Dotty Garvin Tonjes Professor of Electrical and Computer Engineering. Boltasseva's interdisciplinary work merges nano-optics, [materials science](#) and machine learning to enable a new generation of devices for ultra-fast, ultra-thin optics, denser photonic/quantum circuitry and [data storage](#), harsh environment sensing, biomedical applications, energy conversion and room-temperature, efficient quantum devices.

Vladimir M. Shalaev, the Bob and Anne Burnett Distinguished Professor of Electrical and Computer Engineering and scientific director for nanophotonics at Birck Nanotechnology Center in Purdue's Discovery Park. Shalaev is recognized for his pioneering studies of linear and nonlinear optics of random nanophotonic composites, artificially designed and engineered optical metamaterials, plasmonics and quantum photonics.

Researchers combined [titanium nitride](#), a refractory metal pioneered by the Shalaev-Boltasseva research groups, that has an exceptionally high laser tolerance, with extremely short laser pulses consisting of a mere few electric field oscillations. Titanium nitride's 10-times larger laser tolerance than gold enabled researchers to hit it with high intensity radiation, emitting shorter wavelength light at up to 110 nm, in the vacuum ultraviolet regime for the first time in a metal.

More information: A. Korobenko et al, High-harmonic generation in metallic titanium nitride, *Nature Communications* (2021). DOI: [10.1038/s41467-021-25224-z](https://doi.org/10.1038/s41467-021-25224-z)

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