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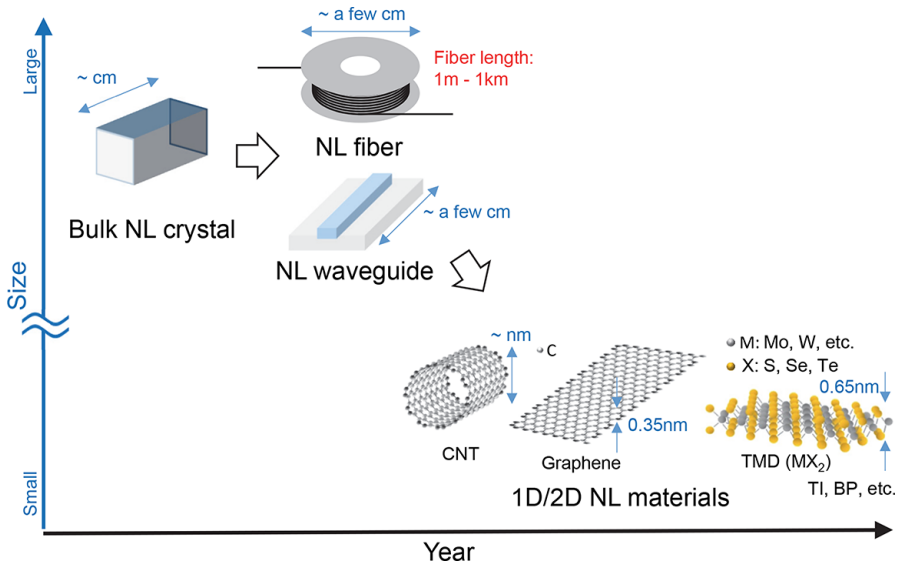
Carbon nanotubes and graphene remain the best options for short-pulse fiber lasers.



1D and 2D carbon materials — graphene and carbon nanotubes — seem to be the materials of the future. Due to their electrical, optical, chemical and mechanical properties, these materials are quickly finding applications in a range of technologies, such as nonlinear optics. A new tutorial by Shinji Yamashita focuses on the linear and nonlinear optical properties for these materials.

Graphene, with its 2D honeycomb molecular lattice, has a unique band structure, which provides it with unusual electric transport phenomena and valuable optical properties. Often graphene sheets are rolled into carbon nanotubes via various chemical vapor deposition methods. Both materials have many practically useful properties such as saturable absorption, electro-optic effect, and the nonlinear Kerr effect. Saturable absorption — optical absorption due to electronic transitions between energy levels — is fast in both graphene and carbon nanotubes. The nonlinear polarization of electrons in the honeycomb lattice likely contributes to a large nonlinear refractive index change, also known as the nonlinear Kerr effect.

The ultra-nonlinear phenomena these materials possess make them beneficial for applications like short-pulse fiber lasers, electro-optic modulators, and all-optical signal processing devices. Carbon nanotubes are particularly useful for mode locking, a method of generating ultrashort optical pulse train useful in short-pulse fiber lasers. Graphene, with broad wavelength coverage, is especially handy for midinfrared lasers. The tutorial reviews other new materials but finds standard carbon nanotubes and graphene remain the best option for short-pulse fiber lasers in terms of fabrication cost, robustness and high-power endurance.

Source: "Nonlinear optics in carbon nanotube, graphene, and related 2D materials," by Shinji Yamashita, *APL Photonics* (2018). The article can be accessed at https://doi.org/10.1063/1.5051796.