

# Feature issue introduction: nanocarbon for photonics and optoelectronics

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**Abstract:** Nanocarbons possess a variety of nearly ideal, low-dimensional nanostructures that cause them to attain unique electronic and optical properties. Recent linear and nonlinear spectroscopic and optoelectronic results prove that they have much to offer in the photonics arena. This feature issue presents reviews and research articles in the area of nanocarbon optics and optoelectronics, which help to summarize the emerging broad range of applications and to expand the understanding of their properties.

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## References and links

1. D. H. Seo, S. Kumar, A. E. Rider, Z. Han, and K. Ostrikov, "Deterministic control of structural and optical properties of plasma-grown vertical graphene nanosheet networks via nitrogen gas variation," *Opt. Mater. Express* **2**(6), 700–707 (2012).
2. A. Mock, "Padé approximant spectral fit for FDTD simulation of graphene in the near infrared," *Opt. Mater. Express* **2**(6), 771–781 (2012).
3. T. D. Nguyen, S. Liu, M. D. Lima, S. Fang, R. H. Baughman, A. Nahata, and Z. V. Vardeny, "Terahertz surface plasmon polaritons on freestanding multi-walled carbon nanotube aerogel sheets," *Opt. Mater. Express* **2**(6), 782–788 (2012).
4. Q. Zeng, S. Wang, L. Yang, Z. Wang, T. Pei, Z. Zhang, L.-M. Peng, W. Zhou, J. Liu, W. Zhou, and S. Xie, "Carbon nanotube arrays based high-performance infrared photodetector [Invited]," *Opt. Mater. Express* **2**(6), 839–848 (2012).
5. Z. Pan, H. Gu, M.-T. Wu, Y. Li, and Y. Chen, "Graphene-based functional materials for organic solar cells [Invited]," *Opt. Mater. Express* **2**(6), 814–824 (2012).
6. M. Pokrass, Z. Burshtein, R. Gvishi, and M. Nathan, "Saturable absorption of multi-walled carbon nanotubes/hybrid-glass composites," *Opt. Mater. Express* **2**(6), 825–838 (2012).
7. D. R. B. Valadão, D. G. Pires, M. A. R. C. Alencar, J. M. Hickmann, C. Fantini, M. A. Pimenta, and E. J. S. Fonseca, "Investigation of the electronic nonlinear refraction index of single-wall carbon nanotubes wrapped with different surfactants," *Opt. Mater. Express* **2**(6), 749–756 (2012).
8. B. A. Ruzicka, S. Wang, J. Liu, K.-P. Loh, J. Z. Wu, and H. Zhao, "Spatially resolved pump-probe study of single-layer graphene produced by chemical vapor deposition [Invited]," *Opt. Mater. Express* **2**(6), 708–716 (2012).
9. C. Mou, R. Arif, A. Rozhin, and S. Turitsyn, "Passively harmonic mode locked erbium doped fiber soliton laser with carbon nanotubes based saturable absorber," *Opt. Mater. Express* **2**(6), 884–890 (2012).
10. G. Q. Xie, J. Ma, P. Lv, W. L. Gao, P. Yuan, L. J. Qian, H. H. Yu, H. J. Zhang, J. Y. Wang, and D. Y. Tang, "Graphene saturable absorber for Q-switching and mode locking at 2  $\mu\text{m}$  wavelength [Invited]," *Opt. Mater. Express* **2**(6), 878–883 (2012).
11. W. F. Zhang, L. B. Tang, S. F. Yu, and S. P. Lau, "Observation of white-light amplified spontaneous emission from carbon nanodots under laser excitation," *Opt. Mater. Express* **2**(4), 490–495 (2012).

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Nanocarbon materials are attractive building blocks for future nanoelectronic and nanooptic devices, because they allow achieving new degrees of both performance and functionality—a combination unachievable by most conventional materials.

Nanocarbons possess a variety of nearly ideal, low-dimensional nanostructures with unique properties across a range of physical phenomena ranging from mechanics, thermal physics, and electrochemistry to optics. These, in turn, make them ideal not only for a wide range of applications but as a test bed for fundamental science. Their specific properties are chiefly governed by quantum physics and/or surface effects, and they are significantly

different from equivalent macroscopic objects. Structure control is therefore a most crucial issue and a topical research field.

Nanocarbon occurs in six different basic forms: graphene, graphite, fullerenes, nanodiamond, nanotubes, and nanocones. Since the discovery of fullerenes and carbon nanotubes about two decades ago, steady scientific and technological progress on numerous aspects of research related to synthesis, purification, structure, properties, and applications has been observed, as is typical for any new and novel material.

Recent linear and nonlinear spectroscopic and optoelectronic results prove that they have much to offer in the photonics arena. This feature issue presents reviews and research articles in the area of nanocarbon optics and optoelectronics, which help to summarize the emerging broad range of applications and to expand the understanding of their properties.

The close relationship between controlled nanoscale structure and optical properties is described for graphene nanosheets by Seo *et al.* [1]. Both graphene and carbon nanotubes are particularly interesting since the optical absorption extends smoothly across an extremely wide wavelength range, including the near infrared studied in the modeling paper by Mock [2], and going as far as the terahertz range surface plasmon polariton absorption described by Nguyen *et al.* [3] in carbon nanotube aerogel sheets.

As presented in two invited papers, extending the absorption range into the near infrared is of great practical importance. Zeng *et al.* [4] have achieved a substantial performance enhancement of infrared photodetectors based on carbon nanotube arrays. Pan *et al.* [5] have reviewed the use of neat and chemically modified graphenes to enhance organic solar cell performance. In this case, the unique combination of electrical transport properties, optical transparency, and thermal conductivity achieves substantial device improvements.

The nonlinear optical properties of quantum-confined low-dimensional structures are interesting both as spectroscopic tool from a basic research point of view and as passive mode-locking devices for ultrashort lasers. Pokrass *et al.* [6] have studied saturable absorption in hybrid carbon nanotube/glass composites, Valadão *et al.* [7] have determined the nonlinear refractive index of surfactant wrapped carbon nanotubes, and Ruzicka *et al.* [8] have measured the ultrafast saturation and relaxation behavior of CVD-grown graphene layers. Mou *et al.* [9] have used carbon nanotubes to mode lock an erbium-doped soliton fiber laser, while Xie *et al.* [10] have employed graphene to mode lock a solid-state laser in the upcoming 2  $\mu\text{m}$  wavelength range.

In an extremely interesting paper by Zhang *et al.* [11], white-light amplified spontaneous emission from carbon nanodots is described, pointing the way toward potential lasing application of nanocarbons—a futuristic idea even in an optically pumped context.

In conclusion, this feature issue of *Optical Materials Express* gives a topical and highly interesting overview of the state-of-the-art in the emerging wide-ranging field of nanocarbon photonics research and offers many possibilities for future research. The field spans the entire spectrum from basic materials research to novel materials for laser and optoelectronic device applications.

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