OPTICAL EFFECTS IN SELF-ASSEMBLED ORGANIC FRUSTUM SHAPED MICROSTRUCTURES

E. A. Mamonov [1], I. A. Kolmychek [1], A. I. Maydykovskiy [1], V. B. Novikov [1], T. V. Murzina [1], D. Venkatakrishnarao [2], Y. Narayana[2], R. Chandrasekar [2]

[1] *M. V. Lomonosov Moscow State University, Moscow 119991, Russia; e-mail: murzina@mail.ru*
[2] *School of Chemistry, University of Hyderabad, India*

We discuss photonic effects in self-assembled organic microstructures prepared by self-assembly technique. It is shown that particle composition and geometry brings about a number of unique shape and size dependent optical properties of the structures.

New materials and designs of functional optical elements are continuously very much desired. Well know examples of artificial photonic structures which have already found exciting application are optical fibers, photonic crystals, plasmonic devices etc. A tendency now is to miniaturize further such structures while keeping high functionality. From this point of view, organic solid nano- and microstructures are attracting distinct attention, as they can be potential to act as nanoscale waveguides, high quality factor resonators, circuits, optical filters, modulators, sensors etc. Among these functions, resonators are potentially useful to create optical mode filters, micro lasers, optical switches and ultra-sensitive nano-biosensors. Due to a high degree of the field localization inside such resonating structures they are assumed as a good candidate for microlasers operating in the visible and near infrared spectral range.

Organic solids dipolar molecules possess interesting optical properties; they show photoluminescence spectra that can be controlled by a proper chemical structure design and by the solid state packing via intermolecular interactions. For the photonic applications, the emission spectra can be further fine tuned by a proper choice of novel building block molecules, and assembling the molecules into various geometrical shapes by adopting various fabrication conditions [1, 2]. In the last of couple of years, using self-assembly technique about a dozen organic resonators has been created with shape such as tubes, spheres, hemispheres, and hexagonal plates [3, 4]. However to our knowledge there is no report available on inverted frustum shaped organic whispering gallery modes (WGM) resonators. Therefore, in this paper we present a novel “frustum” shaped micro particles (Fig. 1a,b) self-assembled from a red emitting dye displaying WGM resonance upon optical excitation with visible lasers.

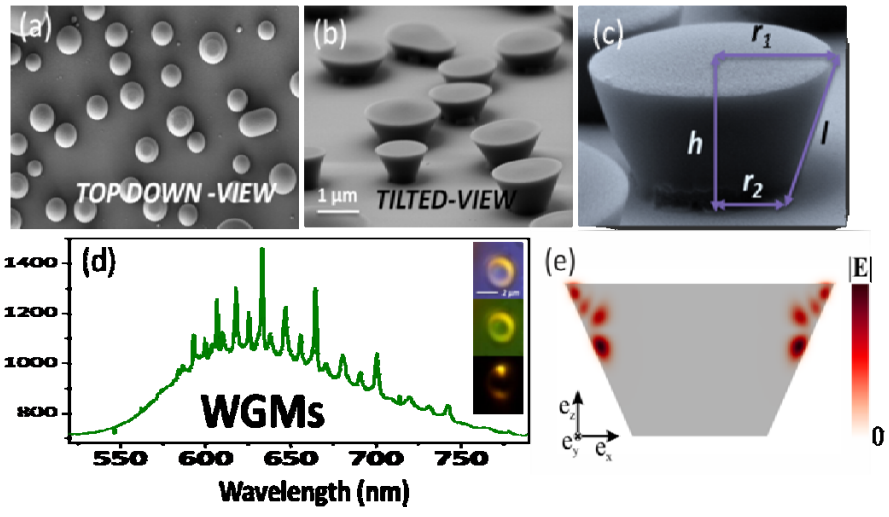

Fig. 1. SEM images of the inverted cones structures formed from DCM dye on a glass substrate on large (a) and smaller (b) scales. c) Single particle SEM image with its geometrical parameters. d) The single particle photoluminescence (PL) spectrum together with WGMs, inset – the micro-PL images of a single cone. e) The results of the numerical calculation of the cross-section of the field amplitude modulus within a single frustum cone with the radiuses r_1 = 1 µm and r_2 = 0.5 µm.

These microstructures are very attractive because during single-particle photoluminescence studies individual particle (Fig. 1c) shows shape and size dependent local field enhancement due to waveguide behaviour as well as the WGM excitation (Fig. 1d). It was demonstrated that a strong amplification of the photoluminescence is attained closer to the outer surface of the cones, similarly to shown on the inset in Fig. 1d, insets. It was also proved

that the spectrum of the PL signal is periodically modulated giving a set of high-quality modes, attributed to the WGM excitation inside the structures (Fig. 1d).

We have also proved this by numerical calculations of the field distribution within a single cone, the results for the cross-section of the modulus of the electric field amplitude corresponding to the excitation of one of the WGMs is shown in Fig. 1e. It is seen that the optical field is predominantly concentrated closer to the cone angles. Spatial field distribution is determined by the definite WGM number. Moreover, the direction of the energy flux is consistent with the WGM excitation and shows that it is rotating inside the structure, i.e. has the opposite signs on different sides of the cones.

In this talk we also present the recent achievements in the field of the organic self-assembled structures and their unique photonic properties. The results of the experimental and numerical studies of optical properties of the structures of various designs are to be discussed.

This work was supported by RSF grant No 16-42-02024.

1. R. Ghadiri, J. R. Granja, R. A. Milligan, D. E. McRee, N. Khazanovich, *Nature*, **366**, 324–327 (1993).
2. P. Hui, R. Chandrasekar, *Adv. Opt. Mater.*, **25**, 2963 (2013).
3. D. Venkatakrishnarao, R. Chandrasekar, *Adv. Opt. Materials*, **4**(1), 112 (2016).
4. U. Venkataramudu, D. Venkatakrishnarao, N. Chandrasekhar, M. A. Mohiddon, R. Chandrasekar, *Phys. Chem. Chem. Phys.*, **18**, 15528 (2016).