MODELLING OF PHOTONIC NANOJET IN SPHERICAL MICROCAVITIES

K.I. Rusakov[1], A.A. Gladyshchuk[1], D. McCloskey[2], J.F. Donegan[2], Y.P. Rakovich[2]

[1]Brest State Technical University, Brest, Belarus
[2]Trinity College Dublin, Dublin, Ireland

In recent years the studies of electromagnetic modes in solid spherical microcavities have been of great interest both for their potential applications and fundamental optical properties. Dielectric transparent microspheres are three-dimensional spherical microcavities which provide high Q-factors and a small mode volume leading to strong optical feedback within the cavity. In this present work, we studied the optical properties of spherical micrcavities with regards to resonance modes and directional beam emission by means of photonic nanojets.

They emerge on the shadow side of the surface of a dielectric microcavity illuminated by plane wave. The unique feature of nanojets is a directional beam with a beam waist smaller than the half of wavelength. In fact, a transverse beamwidth as small as 0.3 λ has been reported. In contrast to diffraction-limited microlensing, the nano-jet phenomenon is a near-field effect due to the proximity of the focus position and the microsphere surface. Also because of the nano-scale beam waist, the photonic nanojets can reach a very high intensity. One of the motivations for our research is to examine the feasibility of subdiffractional resolution of imaging and sub-wavelength optical signal waveguiding.

We use the finite element method to study the properties of these jets such as beam waist, focal intensity, divergence angle, as a function of refractive index and incident beam diameter. On this way we explore the dependence of the jet properties of this system, proposing propose the optimum sphere size, wavelength and refractive index to minimise the full width at half maximum of the photonic nano-jet, while maximising the power in the jet. Our angular spectrum analyses of the photonic nanojets reveals that it is the higher order spatial frequency components bellow the light cone that contribute to the PNJs shape and not the evanescent components.

In applications requiring a high conversion efficiency between laser power and heat in small localised area, such as in Scanning Near field optical Microscopy (SNOM) and Nanolithography, photonic nanojets are much more efficient than conventional solid immersion lens methods, as the jet is propagating field, and not evanescent one.