Random Laser materials: from ultrahigh efficiency to Anderson localization transition

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Random Lasers hold the premise for cheap coherent light sources that can be miniaturized and molded into any shape and used for speckle-free imaging in biology, remote sensing, display technology, encrypting, cancer detection and distributed amplification [1]. However, they require improvements specifically in terms of efficiency. This work details for the first time a strategy for increasing the efficiency of a random lasers that consists in using smaller particles, trapped between large particles to serve as absorption and gain centers whereas the large particles control mainly the light diffusion into the sample. A record slope efficiency of 50% was achieved using yttrium vanadate particles of mean particle size of 54 μm by optimizing the distribution of the polydispersed particles. The random lasers have been completely characterized by measurements of backscattering cone, absorption and reflection measurement, etc. in order to determine transport mean free path, l_T, average photon path length and fill fractions.

A similar strategy, this time using a colloidal suspension of core-shell nanoparticles (TiO2@Silica) in ethanol solution of Rhodamine 6G, allowed us to observe the transition regime to Anderson localization [2]. Narrow peaks with similar amplitude overlapped to a super-fluorescence band are observed in the emission spectrum. These narrow peaks show complete suppression of interaction amongst them. The strategy used in these samples relies on the fact that the interaction between scatterers (separation < size) leads to an inhomogeneous distribution of scatterer positions at the microscopic scale, leading to micrometric regions with kl_T values lower than the averaged kl_T value determined experimentally and possibly with kl_T ~1 (Ioffe-Regel criterion).

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