STED-NANOLITHOGRAPHY OF HYBRID PLASMONIC STRUCTURES

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STED-method (STimulated Emission Depletion) is widely used nowadays to overcome the diffraction limit in optical resolution, i.e. STED nanoscopy has become a routine technique in bio-imaging. There are some attempts to transform STED-microscopy towards STED-lithography. While STED-nanoscopy reached resolution better than 10 nm meanwhile, STED-lithography resolution is an order of magnitude worse. Minimal axial feature size for STED-lithography is around 55 nm [1]. STED-lithography nowadays is only used for the photoinduced polymerization. On the other hand, hybrid dye-noble metal nanoparticles (NPs) influence STED-nanoscopy performance [2] in accordance with the formula:

\[
d_{\text{NP}} \approx \frac{\lambda}{2n \sin \alpha \sqrt{1 + \frac{\Gamma_f(r, \lambda_{\text{STEP}})}{\Gamma_f(r, \lambda_{\text{em}})} I_{\text{STEP}} / I_{\text{sat}}}}
\]  

We demonstrate for the first time the application of the STED-nanolithography to the silver photoreduction. There are two competitive processes during hybrid structures formation with STED-method – silver photoreduction and the photoinduced polymerization [3]. We study various factors influence on the process of STED-nanolithography for hybrid system. Morphology and structural parameters of the hybrid nanostructures produced with STED-method also presented. There are two mechanisms of NPs influence on the efficiency of STED-lithography: the dye excited state lifetime changes (due to Purcell effect, quenching, etc) and electromagnetic field enhancement due to localized surface plasmon resonance in NPs. We provided the luminescence kinetics study of hybrids containing silver NPs and photoinitiator dye molecules (DETC) with time-correlated single photon counting (TCSPC) with confocal microscopy (PicoQuant MicroTime200). Silver NPs influence on the physical properties of the DETC manifests itself in the excited state lifetime reduction from 2.3 ns to 0.6 ns. SERS in hybrid structures formed with STED-nanolithography also discussed.

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