The main goals of this research are to delineate the electrospray modes, to achieve subwavelength focusing, and to enable a process for the deposition of nanoparticles into microlayers and discrete nanodots. This process is based on the electrospray of water microdroplets that carry nanoparticles into a hollow laser beam. The laser beam heats the droplets to evaporate the water and simultaneously sinter the nanoparticles to deposit the material on a substrate.

Nanoparticle suspensions of different materials have been deposited using a microdripping electrospray mode. The effect of the physical properties of suspensions on the droplet size and the frequency of droplet formation is described by the relative influence of the electric, gravity, viscous, and capillary forces. A scaling law is derived for this effect to unify the results of different types of suspensions as a correlation with a nondimensional group of parameters. This law can be used to select the electrospray parameters for a nanomanufacturing process.

A Nd:YAG laser of wavelength 1064 nm was focused to accomplish the deposition of nanoparticles. Microdroplets of certain diameters were found to act as superlens to cause subwavelength focusing of the laser beam over a small range of the laser power and thus overcome the diffraction limit. The superlens characteristic of the microdroplets is attributed to three optical phenomena such as Maxwell’s fish eye lens or Lüneberg lens, evanescent waves by laser scattering, and evanescent waves by the total internal reflection principle. A microfluidic cooling effect can also contribute to creating subwavelength features. This study demonstrates an interdisciplinary mechanism to achieve subwavelength focusing during laser materials processing, where microdroplets serve as both a nanoparticle carrier and a superlens.