Optimization of Optical Size Control in Gallium Nanoparticle Growth

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Abstract: We report on a systematic study of the influence of irradiating optical power on the size of gallium nanoparticles grown from an atomic beam. A minimum median diameter is found to be 45 nm.

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We report that a low level of optical excitation provides a substantial influence on the size distribution of gallium nanoparticles grown from the atomic beam on a cryogenic substrate, thus providing a new way of achieving tailored films of nanoparticles with given characteristics [1]. The growth experiments, performed *in situ* in the vacuum chamber of a scanning electron microscope (SEM) equipped with an inverted effusion cell, revealed that the median diameter of the nanoparticles decreases with increasing irradiating optical power, with 0.1, 0.2 and 0.4 mW average power resulting in 70, 50 and 45 nm particles, respectively.

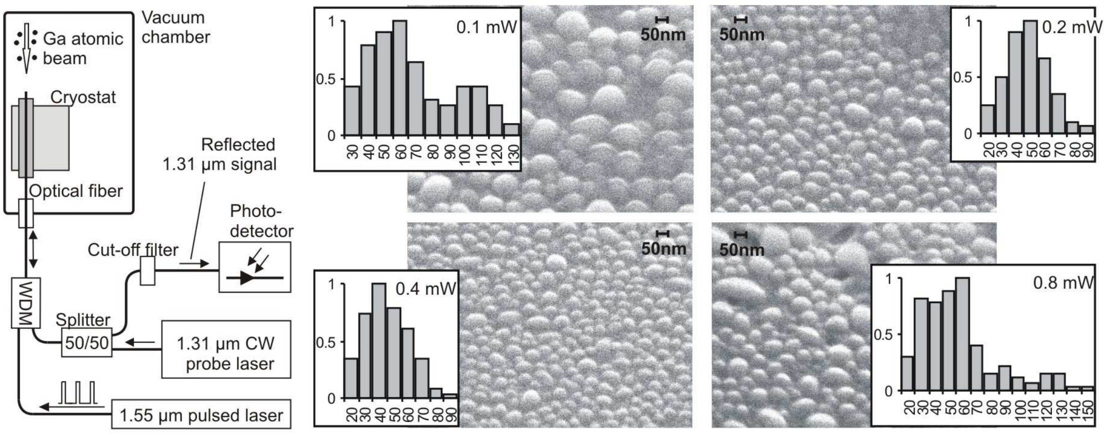

Figure 1. (left) The setup for light-assisted growth of nanoparticles at the end face of an optical fiber, and (right) SEM images of the grown nanoparticles irradiated by 0.1, 0.2, 0.4 and 0.8 mW of average optical power from a pulsed 1.55 µm laser during their growth. The insets show histograms of the size distributions of particles in the respective samples.

The nanoparticles were grown on the end face of an optical single-mode fiber kept at 90 K. During the growth the particles were exposed by light from a 20 kHz / 2.7 ns pulsed 1.55 µm erbium-doped fiber-laser. The deposition was done during 45 min, after which the sample was brought up to 293 K and SEM images were acquired (Fig. 1, right). As shown in the histograms, the nanoparticles grown at 0.2 and 0.4 mW are considerably more monodisperse than those grown at 0.1 mW. Further increasing the power to 0.8 mW, the result is a non-organized film of partially merged particles of median diameter 60 nm, caused by heating from the optical irradiation, which melts and starts merging the nanoparticles [2]. To obtain even smaller particles, one possibility is to use a wavelength close to their plasmon resonance, in the blue-green region.

References

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[2] M. Wautelet, *J. Phys. D: Appl. Phys.* **24**, 343-346 (1991).