High-throughput Synthesis of Silicon Particles with Optical Magnetism

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Introduction. Silicon particles having a certain number of characteristics are attractive as ideal building blocks for metamaterials. For pure silicon, an ideal particle would have a dimensions between 75-200 nm, the particle would be dense and crystalline.[1] The type of materials that can result for their assembly include forward scattering, negative refractive index, beam shaping, wave-front focusing and optical transducers that interface with electronics. Mie resonance in the optical spectrum has been shown through laser printing individual particles and laser annealing.[2] Despite the desirability of silicon particles, their bulk synthesis is elusive.

Aims. Produce bulk quantities of monodisperse, spherical silicon particles supporting Mie resonance in the visible region of the electromagnetic spectrum.

Methods. Amorphous silicon particles were synthestized by thermal pyrolysis of trisilane and (N,N'-diisopropylbutylamidinate)dichlorosilane in supercritical hexane, in using a Ti grade 2 batch reactor, according to a procedure published by J.T. Harris, et al.[3] All the reactions were carried out at 460 °C, for 10 min. Once the reactor cooled, the particles were collected and washed three times with chloroform.

Results and discussion. We reduce the size of Si particles produced by the thermal decomposition of trisilane by adding a second precursor that generates seed particles in situ. By decreasing particle diameter between 200 and 350 nm, electric and magnetic dipole scattering display resonances in the visible region (Fig. 1). The optical scattering properties of these particles were measured with static polarization resolved light scattering, a technique capable of differentiating between pair and impair scattering. The electric dipole and magnetic dipole were resolved. The presence of inclusions led to a coalescence of the two dipole resonances.

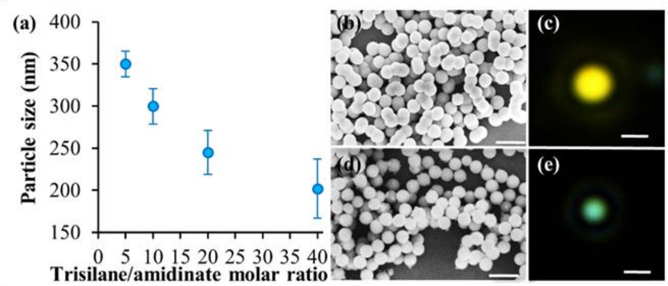

Figure 1. (a) Trend in silicon particle size as a function of trisilane:bisamidinate silicon dichloride concentration. (b,d) SEM images and (c,e) dark field images of the silicon particle light scattering with (b,c) no amidinate and (d,e) 40:1 trisilane:amidinate. The scale bars represent 1 µm.

Conclusion. Optical magnetism in silicon produced using a high throughput method has been achieved using a seeded-growth method. The size of the objects can be controlled by adjusting the ratio of two silane precursors to create monodisperse spheres with scattering tunable from red to blue. These objects are poised to be excellent building-blocks for the production of 3D metamaterials, in the form of films, fibers and free-standing structures.

References

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