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Citation: [AIP Conference Proceedings](#) **899**, 710 (2007); doi: 10.1063/1.2733451

View online: <http://dx.doi.org/10.1063/1.2733451>

View Table of Contents: <http://aip.scitation.org/toc/apc/899/1>

Published by the [American Institute of Physics](#)

Silicon Microspheres for Terahertz Communication

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Abstract. Silicon microspheres can be used for free space optical communication applications in the THz communication bands. The morphology dependent resonances of the microsphere have quality factors of 100000, which provide the narrow linewidths for high resolution filtering, Raman lasers, modulators, and CMOS compatible detectors.

Keywords: microsphere, photonic atom, morphology-dependent resonance, terahertz, wavelength division multiplexing.

PACS: 42.25.-P, 42.25.Fx, 41.20.Jb, 42.50.Pq, 42.55.Sa, 42.60.Da

Morphology dependent resonances (MDR's) of μ -spheres provide the necessary optical feedback for applications in spectroscopy [1]. μ -spheres are uniquely applicable in compact optoelectronic devices for wavelength division multiplexing (WDM) [2].

In this work, we have investigated the mid-IR (THz) free space communication applications of silicon (Si) μ -spheres. Silicon has been the material of choice for the μ -electronics industry for more than half-a-century, and is an inexpensive, plentiful, well understood material. The need for low cost photonic devices has stimulated a significant amount of research in Si photonics, which is currently less well developed as compared to III-V technologies, and is poised to make a serious impact on the telecommunications industry. Silicon μ -spheres are a new paradigm for the use of silicon in optical communication applications.

Elastic light scattering spectra from a Si μ -sphere with radius $a = 25 \mu\text{m}$, and refractive index $m = 3.4224 + 0.00003i$ are calculated. Forward (0°), perpendicular (90°), and backward (180°) elastic scattering spectra are calculated. In the calculations, a plane wave is incident on a Si microsphere of radius $25 \mu\text{m}$ and a refractive index $m = 3.4224 + 0.00003i$. TE represents the plane wave with parallel and TM with perpendicular ($\perp$) polarization to the scattering plane. Due to spatial symmetry, TE and TM components give the same results for 0° and 180° scatterings. But the 90° scattering depends on TE and TM. At 90° scattering only the even mode number (n) MDRs can be observed. Figure 1 illustrates the

results of the backward (180°) scattering. The highest Q factor is on the order of 10^5 . The mode spacing is $0.27 \mu\text{m}$, which correlates well with the calculated value of $0.25 \mu\text{m}$. In the backscattering direction, there is no background.

FIGURE 1. 180° elastic scattering intensity.

In the forward direction there is a background in the spectrum due to the concentration of the incoming beam. With the proper system design, it would be possible to use Si μ -spheres for space and earth based communication. The Si μ -sphere shows promise as a building block for future electro-photonic integration in the mid-IR.

We would like to acknowledge the partial support of this research by the EC Grant No: FP6-IST-511616 PHOREMOST and FP6-IST-003887 NEMO.

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