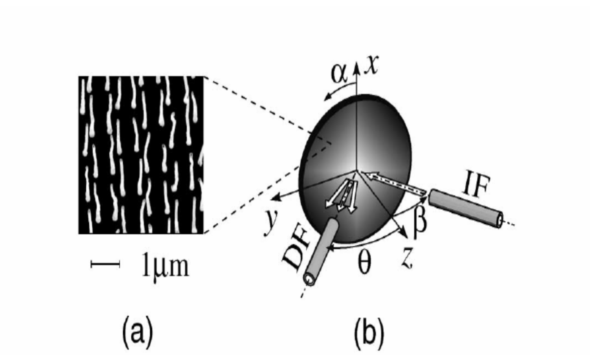
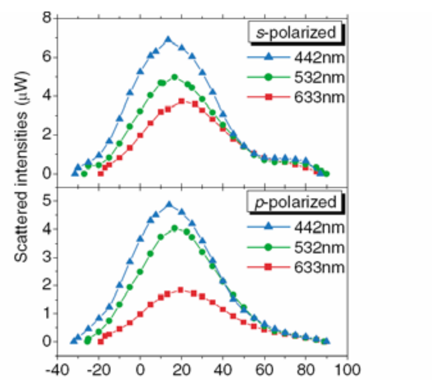
Light Scattering of Periodic β-Aligned Carbon Nanotubes

We reported interesting results of light scattering in periodic β-aligned carbon nanotubes (CNTs).Observations of spatial symmetric scattering as a consequence of strong interference agreed well with analysis of periodic hexagonal lattices of the CNTs. We found that the scattering was maximally enhanced at specific angles where the backward incident and scattered directions were exactly superposed for both s and p polarization. The experimental results also showed that s-polarized incident light was more strongly scattered by the periodic nanotubes than p-polarized light. This was also in conformity with our model using surface plasmons. This phenomenon may be explained through the use of projective geometry of electric field vector and the topological structure of the nanotubes. It is known that CNTs are formed with graphite sheets rolled up in cylindrical form. The electrons move more easily within the graphite sheet than between the sheets. Thus, the surface plasmons are much more easily excited by the light field with electric vector parallel to the nanotube surface. The electric field in s-polarized light is parallel to the nanotube graphite surface all the time when changing the incident light angle. On the other hand, the electric field in p-polarized light is divided into two projections: one along the nanotube surface and the other normal to the surface. Therefore, s-polarized light induced more intensely enhanced backward scattering than p-polarized light in our periodic β-aligned CNTs. The diffraction efficiency observed is about 5% for normal incidence using a 442 nm laser beam. Considering the loss due to the imaginary dielectric coefficient, the diffraction efficiency was at least 10% for our samples. Our results on the periodically aligned CNTs are useful in photonics, such as for the design of appropriate filters for wavelength division and multiplexing applications. These CNTs may also be integrated with photo- or electro-active materials for exploring new photonic and optoelectronic applications.



(a) Scanning electron microscope picture of β-aligned CNTs on silicon surface with periodic hexagonal structure. (b) Schematic of compact fiber rotation system for investigation of the three-dimensional light scattering from the sample surface. IF: illumining fiber; DF: detecting fiber.



Dependence of scattered intensities on incident angle with different incident wavelengths and polarizations. Three cw lasers—633 nm He-Ne, 532 nm Nd:YAG, and 442 nm He-Cd—are used as incident beams. The incident beam diameter is about 2 mm on the sample surface. The intensity is 1 mW for both *s*- and *p*-polarized beams of all wavelengths

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