Synthesis of photoluminescent silicon nanoparticles by simple mechanical-milling for optoelectronics

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It is possible to make light emissive silicon (Si) nanoparticles using ball-milling technique. In the present work it is reported that simply mechanically-milled Si particles can show photoluminescence (PL) at room temperature when their size reduces to less than 5 nm. The blue-shift in their luminescence spectra is also observed. These facts can make them very good potential candidate for their application in optoelectronic devices.

We observed room temperature PL in visible spectrum (table 1) from the milled Si particles and determined their size by the model given by G. C. John et al. [1]. These particles gave PL in visible region when their dimension was found to be in nm range (<5 nm). The results obtained are consistent with those obtained by S. Yerci et al. [2], however it is the first time when such PL was observed from Si nanoparticles synthesised in simple and economical way. The blue shifts (the compaction in wavelength i.e. shifting of wavelength towards the blue line 475 nm) from these particles are observed.

Table 1: Comparative study of PL spectra of ball-milled Si particles

Milling time (h)	Milling speed (rpm)	Material system of ball and bowl	Number of prominent peaks in PL spectra	PL peak position (nm)	Particle size calculated using model given in [1] (nm)
201	400	Agate	1	698	2.50
114	500	Agate	2	693	2.48
				536	1.92
126	500	Agate	2	690	2.47
				535	1.92
252	500	Agate	2	699	2.51
				531	1.91
63	400	WC	1	693	2.48
101	400	WC	2	688	2.46
				749	2.73
194	400	WC	3	566	2.02
				694	2.48
				745	2.70

The PL spectra and the scanning electron microscopy (SEM) for a typical case of 201 h and 400 revolution per minute (rpm) ball-milled Si sample in ethanol medium with ball and bowl of agate are shown in Figure 1. Such easy ball-milling produces clustered Si nanoparticles, which may be caused by mechanical energy generated during the milling process. These clusters are indeed observed by the SEM in extended prolate and spheroid forms.

Figure 1: PL spectra and SEM image of 201 h, 400 rpm ball-milled Si sample with ball and bowl of agate

The milled Si particles smaller than 5 nm can exhibit PL at room temperature and this can make them very significant for optoelectronic device applications, such as, in light emitting diodes (LEDs) and lasers.

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References

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