A study of laser-induced blue emission with nanosecond decay of silicon nanoparticles synthesized by a chemical etching method

Abdulaziz A Bagabas1,4, Mohammed A Gondal2, Mohammed A Dastageer2, Abdulrahman A Al-Muhanna3, Thaar H Alanazi1 and Moath A Ababtain3

1 Petroleum and Petrochemicals Research Institute (PAPRI), King Abdulaziz City for Science and Technology (KACST), PO Box 6086, Riyadh 11442, Saudi Arabia
2 Physics Department and Center of Excellence in Nano Technology (CENT), King Fahd University of Petroleum and Minerals, PO Box 5047, Dhahran 31261, Saudi Arabia
3 National Nanotechnology Center (NNC), King Abdulaziz City for Science and Technology (KACST), PO Box 6086, Riyadh 11442, Saudi Arabia

E-mail: abagabas@hotmail.com

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Abstract
Silicon nanoparticles (Si NPs), exhibiting a strong visible photoluminescence (PL), have found many applications in optoelectronics devices, biomedical tags and flash memories. Chemical etching is a well-known method for synthesizing orange-luminescent, hydride-capped silicon nanoparticles (H/Si NPs). However, a blueshift in emission wavelength occurs when reducing the particle size to exciton Bohr radius or less. In this paper, we attempted to synthesize and characterize H/Si NPs that emit lower wavelengths at room temperature. We proved that our method succeeded in synthesizing H/Si NPs with emission in the blue region. The wavelength-resolved and time-resolved studies of the PL were executed for H/Si NPs in methanol (MeOH), pyridine (py) and furan, using the 355 nm pulsed radiation from a Nd:YAG laser. In addition, excitation wavelength-dependent and PL studies were executed using the spectrofluorometer with a xenon (Xe) broadband light source. We noticed solvent-dependent PL spectra with sharp peaks near 420 nm and a short lifetime less than 100 ns. The morphology and particle size were investigated by high resolution transmission electron microscope (HRTEM). Particles as small as one nanometer were observed in MeOH and py suspensions while two-nanometer particles were observed in the furan suspension.

1. Introduction
Silicon nanoparticles exhibit size-dependent PL quantum yields in the visible spectral region at room temperature, and hence Si NPs have gained an enormous significance. Due to this unique PL behavior, Si NPs finds an important place in a broad range of applications such as optoelectronic, light-emitting devices, sensors, optical communication, photopumped tunable lasers and bio-tagging (Chaabane et al 2004). As the Si NPs size is a crucial factor that controls the emission wavelength of the PL, the method of preparation of the Si NPs is of great importance. Numerous methods have been employed for the synthesis of Si NPs. They are (i) chemical reduction of silicon tetrachloride, (Shirahata et al 2009, Baldwin et al 2006, Liu and Kauzlarich 2002, Mayeri et al 2001, Heath 1992), (ii) thermal decomposition of silanes (Holmes et al 2001), (iii) laser photolysis of silane precursors (Cannon et al 1982), (iv) carbon-dioxide-laser-induced pyrolysis (Li et al 2004, Kirkey et al 2004), (v) laser vaporization-controlled condensation (LVCC) (Germaneko