The auto-formation of silicon quantum dots embedded in a silicon nitride matrix on the surface of different substrates

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A proper control of the luminescence from silicon quantum dots (SiQDs) would allow their commercial use in technologies ranging from artificial lighting to optical computing applications. To imbibe SiQDs in a silicon nitride (Si3N4) thin film is a good option for technology transfer because Si3N4 has a good concentration of charge carriers and a moderate band gap that enables low turn on voltages in operational devices.

Multiple studies have shown that quantum confinement effect is to a great extent responsible of the absorption-emission characteristics of SiQDs embedded in a Si3N4 matrix. In other words, in those systems it is possible to tailor (within certain limits) absorption, emission or both by changing the SiQDs average size and population density. This design capability make these systems very attractive because they can be used not only in electroluminescent or optoelectronic devices but also in sensors and solar cells.

In this work we present a comprehensive analysis based primarily on High Resolution Transmission Electron Microscopy (HRTEM) in order to report the SiQDs characteristics of five embedded systems, each one growth by RPECVD on the surface of: n-type single crystalline (100) silicon wafer, fused silica, highly oriented pyrolytic graphite (HOPG), muscovite mica and single crystalline potassium chloride. We found that the growths on single crystalline silicon and fused silica have SiQDs with better luminescence characteristics i.e. reduced average size and high population density, these two substrates are followed by the HOPG which also exhibits acceptable SiQDs properties. Meanwhile muscovite mica and potassium chloride show the worst SiQDs characteristics i.e. bigger average sizes and populations without normal distributions. We conclude that chemical affinity between the substrate and the precursor gases is the most important parameter in order to achieve SiQDs formation and reproducibility.

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