Room-temperature single electron transport properties in silicon quantum dots for single electron device applications

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Single electron phenomena in nanoelectronic devices have been a subject of extensive studies because nanoelectronic devices are expected to provide a breakthrough in electronics industry forced into a successive miniaturization and ultra low power operation. In addition, single electron effects allow us to propose new device concepts such as a single electron logic, single electron memory, and high precision electrometry(1,2). In this work, we report on the single electron transport properties in silicon quantum dots (Si QDs) at room temperature. The Si QDs were spontaneously grown in silicon nitride film by plasma-enhanced chemical vapor deposition using SiH_4 and NH_3 gases. In order to study the single electron transport properties, metal-insulator-metal (MIM) devices containing the Si QDs were fabricated. The MIM device showed a clear Coulomb staircase and differential conductance peaks at room temperature, indicating that the single electron addition energy of the Si QD is about 67 meV. The measured single electron addition energy of 67 meV can be explained by the charging energy without any contribution from the energy level spacings due to the 12-fold degeneracy of the lowest conduction energy level of the Si QD(3). The size distribution of the Si QDs determined by high-resolution transmission electron microscopy suggests that the single electron addition energy of 67 meV was attributed to the charging energy of 63 meV of the largest Si QDs with the diameter of 4.7 nm among the various-sized Si QDs, since the electrons can start to tunnel through the largest Si QDs due to their smallest band-gap and charging energies(4).

참고문헌

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