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Nanocrystal silicon growth under electron irradiation

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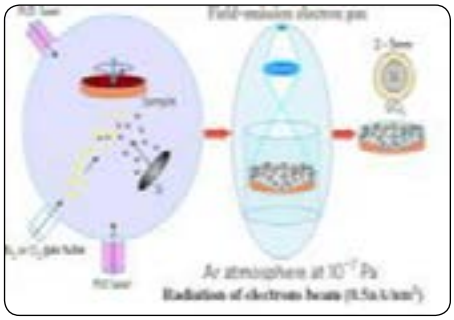
In our experiment, it was observed that silicon nanocrystals rapidly grow with irradiation of electron beam on amorphous silicon film prepared by pulsed laser deposition (PLD), and silicon nanocrystals almost occur in spherical shape on smaller nanocrystals with less irradiation time of electron beam. It is very interesting that magical electron affection promotes growth of nanocrystals due to nanoscale characteristics of electronic de Broglie wave which produces resonance to transfer energy to atoms. In the process, it was investigated that condensed structures of silicon nanocrystals are changed with different impurity atoms in silicon film, in which localized states emission was observed. Through electron beam irradiation for 15 min on amorphous Si film doped with oxygen impurity atoms by PLD process, enhanced photoluminescence emission peaks were observed in visible light and electroluminescence emission was manipulated into the optical communication window on the bigger Si-Yb-Er nanocrystals after irradiation of electron beam for 30 min.



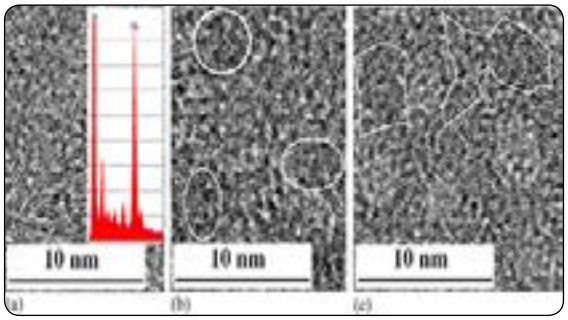


Figure 1: Combination fabrication system with electron beam irradiation device, PLD and pulsed laser etching (PLE) devices, in which at first the amorphous Si film forms, then Si nanocrystals grow up under irradiation of electron beam and Si QDs embedded in SiOx or in SiyNx are produced.

Figure 2: TEM images of Si nanocrystals growing process. (a) TEM image of Si–Yb–N structure on amorphous film after irradiation of electron beam for 5 mins, in which not only QDstructure has been observed, and inset shows composition of Si and Yb in X-ray energy spectrum on the amorphous film. (b) TEM image of Si–Yb QDs embedded in SiyNx amorphous film after irradiation of electron beam for 20 mins. (c) TEM image of Si–Yb nanocrystals with various shapes embedded in SiyNx amorphous film after irradiation of electron beam over 30 mins, in which QDs structure has been broken.

Recent Publications

1. Wei-Qi Huang, Shi-Rong Liu, Zhong-Mei Huang, Ti-Ger Dong, Gang Wang, et al. (2015) Magic electron affection in preparation process of silicon nanocrystal. Scientific Reports 4:9932.
2. Shi X, et al. (2014) Temporal femtosecond pulse shaping dependence of laser-induced periodic surface structures in fused silica. J. Appl. Phys. 116:033104.
3. Huang W Q, et al. (2012) Electronic states and curved surface effect of silicon quantum dots. Appl. Phys. Lett. 101:171601.
4. Liu C-Y, Holman Z C and Kortshagen U R L (2010) Optimization of Si NC/P3HT hybrid solar cells. Adv. Funct. Mater. 20:2157–2164.
5. Godefroo S, et al. (2008) Classification and control of the origin of photoluminescence from Si nanocrystals. Nature Nanotech. 3:174–178.

Biography

Wei-Qi Huang is the Collaborator and Head of Pulsed Laser Etching (PLE) and Pulsed Laser Deposition (PLD) Research Laboratory and Institute of Nanophotonic Physics at Guizhou University. He has a long-established international record in PLE and PLD grown nanosilicon and nanosemiconductor quantum materials and development of their applications in optoelectronics. He has led PLE and PLD research activities at Guizhou University since 2003, with a focus on a variety of semiconductor materials and nanostructures including Si and Ge quantum dots (QDs), quantum wells (QWs) and nanowires (NWs) on Si. He has recently investigated the simulation model of quantum chemistry calculation on impurities atoms bonding on nanosilicon. He has published 80 papers exclusively in PLE and PLD grown Si and Ge nanostructures and devices in peer-reviewed journals including *Nature Scientific Report, Applied Physics Letters, Optics Letters,* and two book chapters. He has a strong record of leading PLE and PLD-related research in the projects funded by NNSFC.

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