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Lanthanum Fluoride with Embedded Silicon Nanocrystals: A Novel Material for Future Electronic Devices

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Abstract : Investigation on Lanthanum Fluoride LaF3 layer embedding Silicon Nanocrystals (Si-NCs) fabricated using a novel one-step chemical method has been reported in this presentation. Application of this material has been tested for low-voltage operating non-volatile memory and Schottkey-junction solar cell. Colloidal solution of Si-NCs in hydrofluoric acid (HF) was prepared from meso-porous silicon by ultrasonic vibration (sonication). This solution prevents the Si-NCs to be oxidized. On a silicon (Si) substrate, LaCl3 solution in HCl is allowed to react with the colloidal solution of prepared Si-NCs. Since this solution contains HF, LaCl3 reacts with HF and produces LaF3 crystals that deposits on the silicon substrate as a layer embedding Si-NCs. This a novel single step chemical way of depositing LaF3 insulating layer embedding Si-NCs. The X-Ray diffraction of the deposited layer shows a polycrystalline LaF3 deposition on silicon. A non-stoichiometric LaF3 layer embedding Si-NCs was found by EDX analysis. The presence of Si-NCs was confirmed by SEM. FTIR spectroscopy of the deposited LaF3 powder also confirmed the presence of Si-NCs. The size of Si-NCs was found to be inversely proportional to the ultrasonic power. After depositing proper contacts on the back of Si and LaF3, the devices have been tested as a non-volatile memory and solar cell. A memory window of 525 mV was obtained at a programming and erasing bias of 2V. The LaF3 films with Si NCs showed strong absorption and was also found to decrease optical transmittance than pure LaF3 film of same thickness. The I-V characteristics of the films showed a dependency on the incident light intensity where current changed under various light illumination. Experimental results show a lot of promise for Si-NCs-embedded LaF3 layer to be used as an insulating layer in MIS devices as well as an photoactive material in Schottkey junction solar cells.

Keywords : silicon nanocrystals (Si NCs), LaF3, colloidal solution, Schottky junction solar cell
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