Synthesis and Characterisation of Erbium Nano Particle doped High k Dielectric Thin film for Novel device Applications

Vikram Singh [(1)*] (IEEE student member), Satinder Kumar [(2)],Dinesh Kumar[(3)], R.K. Nahar[(1)]

[1]Central Electronics Engineering Research institute, ,Pilani-333031 India
(Council of Scientific and Industrial Research) Email: vikram@ceeri.ernet.in
[2]Indian Institute of Technology (I.I.T.) Kanpur-208016, UP(India),
[3]Electronics Science Department**,** Kurukshetra University**,** Kurukshetra-136119,Haryana (India)
[*]Corresponding author

Abstract-In this paper the role of Er nano particles embadded in high k HfO_2 thin films is investigated. Employing MOS structure the electrical and microstructural characterises have been studied for novel device / sensor applications. Details of film deposition and synthesis of Er nanoparticles through reduction of Erbium (III) chloride Hexahydrate. Erbium (III) chloride Hexahydrate and hydrazinium hydroxide is given. For the bifurcation of micro and submicron levels particles in the colloidal solution, the centrifuge of colloidal solution was carried out at 10K RPM for 10 minutes. All the solutions were filtered through a 0.2 micron filter before spin coating. P- type silicon wafers with <100> orientation and 1-10 Ω-cm resistivity were used for the deposition of nano particles on Si substrate. A HRTEM FEI Technai 20 U Twin Transmission Electron Microscope (TEM) was used for observing the morphology and analyzing the size of nanoparticles. The particle sizes were determined by TEM using a FEI Technai Model at 120 kV. Electrical characterization of the MOS capacitor is done and results on I-V and C-V characteristics measured on Kiethley 4200SCS integrated system at different temperatures is presented.

The Er nanoparticles were synthesized through reduction of Erbium (III) chloride Hexahydrate. Erbium (III) chloride Hexahydrate and hydrazinium hydroxide were the guaranteed reagents of Qualigens Fine Chemicals. Di octylsodium sulphosuccinate (AOT) purchased from S.d.fine chem. Ltd.Co. was vacuum dried and stored in a vacuum desiccator before use. HPLC-grade toluene supplied by Loba chemie PVT.Ltd was used. The water used throughout this work was the reagent-grade water produced by the Milli-Q ultra-pure-water purification system.

The microemulsion based Er nanoparticles were prepared through the reduction of Erbium (III) chloride Hexahydrate by $NH_2NH_2H_2O$ in the presence of AOT as a surfactant. Solution A was prepared by dissolving Erbium (III) chloride Hexahydrate (0.01 M) deionized water and AOT (0.05M) in equal volume of deionized water and ethanol under ultrasonication stirring. Solution B was 16ml toluene. Solution C was prepared by dissolving $NH_2NH_2H_2O$ (0.6M) in deionized water. Solution A was injected into solution B in the ratio of water/oil (w/o) emulsion (1:4) at room temperature and the magnetic stirring formed its milky colloidal solution. The colloidal solution was very stable and could be kept for week at room temperature without precipitation.

Nanoparticles usually reach their final sizes within several seconds to several tens of minutes after the addition of solution C so the samples for various analysis were taken after about four hours. For the bifurcation of micro and submicron levels particles in the colloidal solution, the centrifuge of colloidal solution was carried out at 10K RPM for 10 minutes. All the solutions were filtered through a 0.2 micron filter before spin coating. P- type silicon wafers with <100> orientation and 1-20 Ω-cm resistivity were used for the deposition of nano particles on Si substrate. High purity HfO_2 (99.9% purity) target was used to deposit the thin films in MRC rf-sputtering system. The sputtered AlSi thin film about 700 nm was deposited on both side of the wafer, used as top electrode and back contact. The metal film was patterned using photolithography and metal etching. The minimum contact area was 100 by 100μm. The MOS structures were finally annealed in forming gas at 450 ^{0}C.The sample for TEM analysis was obtained by placing a drop of the colloidal solution onto a carbon-covered copper grid and evaporating it in air at room temperature. Before withdrawing the samples, the colloidal solutions were sonicated for 1 min to obtain better particle dispersion on the copper grid. A HRTEM FEI Technai 20 U Twin Transmission Electron Microscope (TEM) was used for observing the morphology and analyzing the size of nanoparticles. The microscope is also equipped with a EDS detector, HAADF detector and Gatan digital imaging system. The particle sizes were determined by TEM using a FEI Technai Model at 120 kV.

Reference

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