Enhanced electrical properties of nitrogen ion implanted epitaxially grown rare earth oxide thin film on silicon

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Epitaxial development of crystalline Gd_2O_3 on silicon in the cubic bixbyite structure exhibits a high band gap of approximately 6 eV, symmetrical band offsets, and only a 0.4 percent lattice mismatch to Si. Layers developed using an optimized process can have sufficiently high k-value, excellent reliability, and high electrical breakdown voltages.[i] The current fascination with the capabilities of spintronic devices has heightened the need to investigate intrinsic ferromagnetic semiconductors, of which the rare earth nitrides are examples. It will be fascinating to learn more about how these materials, rare earth oxides and nitrides, combine to generate rare earth oxynitrides.

The effects of nitrogen incorporation in epitaxial gadolinium oxide (Gd_2O_3) films by high-dose ion implantation on Si (111) after annealing have been explored. Varying the implantation dose changes the nitrogen content of the oxide layer. XPS and AES were used to investigate the presence of nitrogen incorporation on the Gd_2O_3 layer. Nitrogen is thought to be incorporated into Gd_2O_3 via filling oxygen vacancies. After sputter depth profiling, nitrogen reached a maximum concentration of 11% in the interface between the silicon dioxide and Gd_2O_3 layers and the implanted portions of the Gd_2O_3 oxide layer.

In complex oxides grown at a higher temperature, oxygen vacancies (VOs) are the dominant electrically active defect sites, increasing the leakage current. When nitrogen is incorporated in the oxide layer, nitrogen atoms occupy the oxygen vacant sites and therefore change their energy levels and also immobilize the VOs, which may successively reduce the leakage current due to the movement of the VOs. [ii]Ion implantation causes damage to the layer, and it is an effective method for reducing leakage current and enhancing the electrical behaviour of rare earth oxides.

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