Rapid Thermal Oxinitride (RTON) Insulators

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Conventional thermal SiO_2 layers with a thickness less than about 3 - 5 nm cannot provide the electrical quality for ultra large scale integration in silicon microelectronics. Gate dielectrics with better properties in terms of higher stability against hot electron degradation, better diffusion barrier for boron dopants, lower tunneling currents and higher dielectrical constants have to be designed. Thin oxynitride layers with nitrogen concentrations of some percents were found to be a prominent candidate to replace thermal SiO_2. During the last year sub–5nm oxynitride layers were analysed within a large framework and the results were compared with nitridation techniques used before. The new results are to be used for device optimization of vertical and planar MOSFETs.

High resolution elastic recoil detection (ERD) [1] analyses revealed quantitative depth profiles of oxygen and nitrogen in the new devices. Electrical characterisation of the gate materials was done performing GV -, CV -, IV and stress measurements. Using ellipsometric measurements dependencies of the layer thickness were examined.

For the production of oxynitride layers nitrogen was implanted into (100) silicon substrates followed by an oxidation by means of rapid thermal oxidation (RTO) [2]. ERD measurements revealed that the implanted nitrogen diffuses completely from the substrate into the isolation layer (Fig. 1). and predominantly settles at the surface of the insulator. The $Si/Si_xO_yN_z$ interface indicates a comparatively small nitrogen amount. During the first part of the oxidation a oxinitride layer is formed acting as a diffusion barriere for oxygen. Therefore, the growth rate and consequently the layer thickness is reduced.

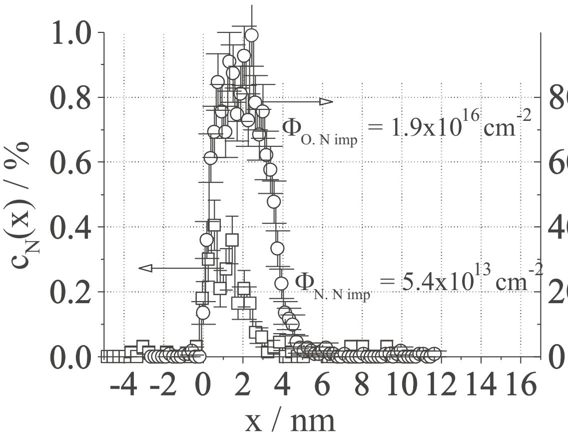

Fig. 1: High resolution ERD depth profiles of oxygen and nitrogen in an oxynitride layer. The oxynitride was processed by RTO of a nitrogen implanted silicon substrate.

Nevertheless, this oxinitride layers show throughout better electrical properties like smaller tunneling currents (Fig. 2), smaller densities of state at the interface (Fig. 3) with respect to conventional silicon oxides.

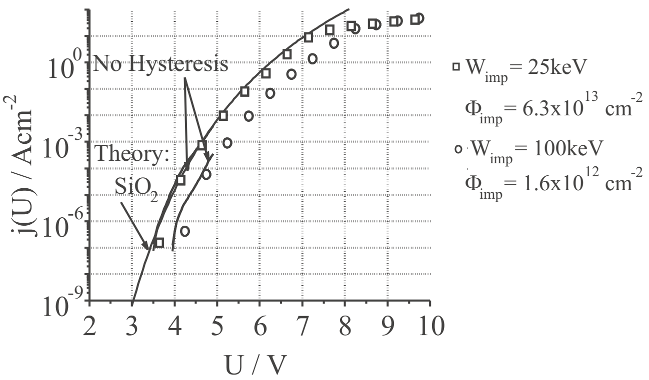

Fig. 2: Tunneling currents for oxynitride layers, processed with different implantation doses and energies.

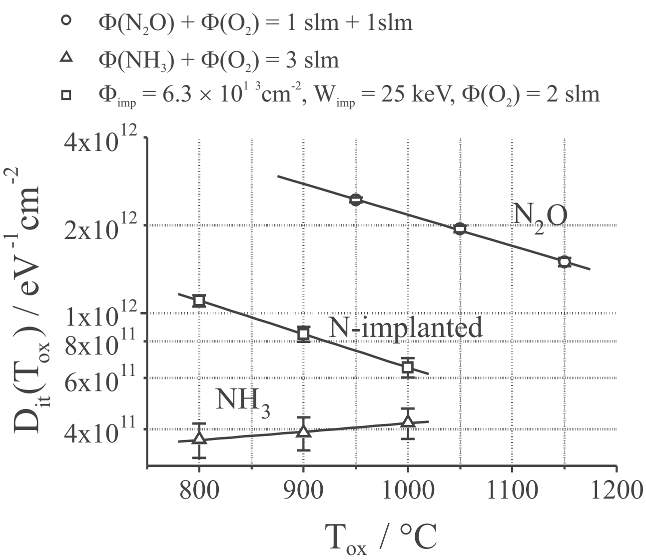

Fig. 3: Interface density of states for different nitridation techniques versus oxidation temperature.

References

[1] G. Dollinger *et al.*,Nucl. Insr. Meth. **B118** (1996) 291
[2] A. Stadler *et al.*, submitted to Microel. Reliab.