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Plasma induced UV/VUV damage during Si and GaN device fabrication

TETSUYA TATSUMI, Sony Corporation

Plasma induced damages (PID) on semiconductor devices have been widely reported. Materials and the interface between stacked materials can be degraded by ions and photons during plasma processes. In this report, I focus on the effect of ultraviolet (UV) and vacuum ultraviolet (VUV) radiation on various devices. In the fabrication of Si-CMOS devices, high-density plasmas are used for dry etching. The light from plasma is absorbed by the materials when its energy is greater than the band gap (Eg). For example, the Eg of the gate SiO2 is about 8.8 eV; consequently the plasma emissions with wavelengths lower than 150 nm are absorbed by SiO2. These VUV lights degrade the surface structure of SiO2 and increase its wet etch rate [1]. SiOCH and ArF photo resist have been used to realize high-speed devices with low power consumption. These materials have a very weak bond, so there are sometimes problems such as increased dielectric constant in SiOCH or a roughening or wiggling of ArF resist caused by UV/VUV [2]. Plasma emission can also affect the electrical and/or optical properties of devices. I investigated the effect of radiation on the interface-trap density (D_{it}) of a SiN/Si structure [3]. When photons in the UV region (200–300 nm) were irradiated, the D_{it} increased and a negative charge was generated in the interface. This indicates that VUV/UV radiation transmitting through the upper dielectrics causes the electrical characteristics of underlying devices to fluctuate. GaN-based semiconductors are used for optoelectronic device applications, so I also investigated the PID of a GaN/InGaN/GaN stacked structure. The samples were exposed to Cl2 plasma emission and analyzed by using photoluminescence (PL). PL intensity decreased when the plasma emission was irradiated. UV radiation (<360 nm) affects damage formation at the InGaN active layer [4]. Monitoring VUV/UV and understanding its effect on surface eactions, film damage, and electrical and/or optical performance are indispensable to fabricate advanced devices.

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