OR2301

Plasma-Enhanced Sputtering Assisted with ICP via New Type of Low-Inductance Antenna for Reactivity-Controlled and Low-Damage Formation of Semiconductor Films

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Plasma-enhanced reactive sputter-deposition process has been developed by installation with a new type of low-inductance antenna (LIA) to sustain inductively coupled plasma (ICP) for enhancement of magnetron discharge and excellent control of reactivity during film deposition. This new type of inductive RF antenna called "inner-type LIA" is embedded in a hall region dug in the chamber wall inner surface. Special feature of the ICP-enhanced magnetron with the inner-type LIA is that the ICP antenna is located at the same height of the target surface for high rate and low-damage deposition. This new-type of the ICP-assisted magnetron has been applied to film deposition of transparent amorphous oxide semiconductor, a-InGaZnOx (a-IGZO) and micro-crystalline silicon films. The target discharge performance exhibited voltage-current characteristics analogous to the properties of the ion saturation current, implying that the plasma density in the vicinity of the target was primarily enhanced by the discharge with the ICP. This feature of the voltage-current characteristics can offer flexible and excellent control of reactivity during film deposition via independent control of the flux ratio of the reactive species to the deposited atoms. The a-IGZO film is expected as a new material for the next-generation thin-film transistor with a considerably higher mobility (> 10 $cm^2(Vs)^{-1}$) than that with amorphous silicon widely used in conventional devices. With this new method of reactivity-controlled deposition, a-IGZO films with mobility as high as 10 $cm^2(Vs)^{-1}$ have been successfully formed without substrate heating. Additionally, silicon film deposition showed low-temperature formation (below 200 deg C) of micro-crystalline silicon films via reactivity control.

Keywords
Plasma-enhanced sputtering
low-inductance antenna
semiconductor film
reactivity control
low damage process