HYPERTHERMAL NEUTRAL BEAM SOURCE WITH LOCALIZED ELECTRON CYCLOTRON RESONANCE PLASMA

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Hyperthermal neutral beams (HNB) have a great potential for semiconductor processes, especially, for etchings and thin film depositions for semiconductor and display fabrications as well as depositions for various thin film applications [1]. Thermal and plasma-induced damages are serious problems for manufacturing deep submicron semiconductor devices and are also expected to be problems for future nanoscale devices. These problems can be overcome by damage-free and low-temperature processes with hyperthermal neutral beams. The HNB process is especially applicable to various thin film growings: Oxidation and nitridation for gate insulators of DRAMs and flash memories, transparent conductive oxide films on organic light emitting diodes (OLEDs) or flexible displays, Si thin films for solar cells and thin film transistors (TFT), and crystal thin film growing for optoelectronic devices such as light emitting diodes (LEDs).

The HNB can be easily produced by neutralization of ion beams extracted from an ion sources. However, it is very difficult to extract a high flux ion beam at a hyperthermal energy range directly from an ion source due to the space charge effect. Instead of direct ion beam extraction, a high flux neutral beam can be obtained at the hyperthermal energy range by accelerating and neutralizing ions in the plasma source with a metal neutralization plate.

High density plasma with a working pressure lower than 1 mTorr is required for such a high flux HNB source in order to reduce the HNB loss due to collisions with the background gas. The plasma should also be so thin that the HNB cannot be lost by reionization during passing through the plasma.

We have developed localized ECR plasma sources with various magnetic field configurations in order to produce high density plasma even at a working pressure lower than 1 mTorr. The plasma density is larger than $5 \cdot 10^{10}$ cm^{-3} at a working pressure of around 0.1 mTorr and the plasma thickness is less than 50 mm. With the ECR plasma, a high flux HNB can be obtained. The energy distributions were measured by a neutral particle analyzer and plasma parameters by electrical probes and optical emission spectroscopy.

1. S. J. Yoo, et al., “Hyperthermal Neutral Beams Sources for Material Processing”, Rev. Sci. Instrum., **79**, 02C301 (2008).