Millatron system

The Millatron system consists of a vacuum chamber with a rotational sample stage and end point detector, a plasma beam source with an RF power supply, a DC supply which controls a magnet (Helmholtz coils) in the ion gun and a MFC with lets high purity Ar into the system.

COPRA 260 has been selected as the plasma bean source in our Millatron. COPRA is a filamentless, radio frequency (RF) driven, low-pressure plasma beam source. The RF power is inductively coupled to the plasma through a matching network and a single-turn excitation electrode. An essential feature of the design is the tunable matching network which is incorporated into the source. The matching network comprises two resonant circuits which employ variable capacitors to match impedance and hence maximize the power transfer efficiency to the plasma. Remotely matched sources are also available upon request. The necessary “resonant” excitation of the plasma is achieved by applying a weak transverse magnetic field generated by means of a series of built-in Helmholtz coils. The strength of the magnetic field is controlled by an auxiliary power supply.

The beam produced by the COPRA is also quasi-neutral i.e. it contains roughly the same number of ions and electrons permitting deposition, etching and surface modification of both conducting and insulating substrate materials without significant charge build-up. The plasma is typically ignited by the creation of a pressure pulse. The process gas is fed directly into the excitation cavity of the plasma source.

The base pressure of the system is typically $2 \times 10^{-7}$ mTorr and the working pressure is $5 \times 10^{-5}$ mTorr using 0.14 sccm of argon. RF power of 400 W is used with a magnet current of 3.5 A. The sample is rotated in a planetary fashion at 45° to the ion beam.

End Point Detector

One of the most important issues in ion milling processes is how to precisely control and stop the milling process at certain layers in the multilayer stacks. In the case of MgO-based MTJs, the ideal end point for the definition the small junction is the 0.8 nm Ru in the AAF [artificial antiferromagnet] layers (IrMn/CoFe/Ru/CoFeB). For this purpose, a high sensitive Hiden end point detector (EPD) was installed on the top of Millatron.

The Hiden EPD consists of ion milling probe, radio frequency (RF) head with amplifier and PC running MASsoft. The ion milling probe contains an energy filter, a quadrupole mass spectrometer and a secondary electron multiplier detector. Any ions entering the quadrupole field experience potential differences deflecting them from their original trajectory. The extent of deflection of any ion entering the field is related to its mass: charge (m/e) ratio. At each interval on the RF scan only one m/e ratio resonates with the field allowing the ion to pass along the z-axis. All other species are deflected and neutralized by impact upon the rods of the quadrupole. The ion signal then collected and displayed by the MASsoft. By the monitor of the software, a certain end point of the ion milling process can be easily set.