ORG105

Chlorine-based plasma etching of Fe-Cr alloys for the development of steel patterning: modeling, plasma diagnostics and etching rate measurements

Feriel Laourine[1], Guillaume Ledaim[2], Ahmed Rhallabi[2], Gregory Marcos[1], Stephane Guilet[3], Cedric Noel[1], Gerard Henrion[1], Thierry Czerwiec[1]

[1]Institut Jean Lamour, Nancy, France [2]Institut des materiaux Jean Rouxel, Nantes, France [3]Centre de Nanosciences et de nanotech., Palaiseau, France

feriel.laourine@univ-lorraine.fr

Surface structuring is highly developed in microelectronics through plasma etching processes. The patterning of metallic materials is currently arousing great interest by its numerous applications on various fields including wettability, adhesion, self-cleaning, drag reduction, friction (lubricated or not), biotechnologies, etc. However, there are very few studies devoted to the etching of austenitic or ferritic steels. The approach developed in this study consists in using both modeling and experimental approaches to understand more about the Fe-Cr alloys etching under an ICP chlorine plasma. Experiments have been carried out in an ICP/RIE SENTECH device delivering a 800W RF power with a chlorine plasma operated at 5 mTorr pressure with a substrate temperature up to 220 °C and – 150 V DC bias on pure iron and five Fe-Cr alloys with up to 12 wt% of Cr. The etching rate is higher for pure iron (around 270 $nm.min^{-1}$) and decreases to 70 $nm.min^{-1}$ as the chromium content increases in the alloy. Optical emission spectroscopy measurements show that the introduction of Fe or Cr samples in the plasma reactor, even in small quantities, strongly affects the plasma. The etching simulator developed in this study is based on the multiscale approach, which allows us to follow the steel etch profile evolution as a function of the operating conditions such as pressure, RF power, gas flow rate and DC bias. Cellular Monte-Carlo approach is used to quantify the etching kinetics of steel through the mask. The output parameters in terms of positive ions and reactive neutral fluxes as well as the Ion Angular Energy Distributions Functions IAEDFs calculated from the plasma and sheath models are introduced as input parameters in the surface model. Experiments show a strong decrease of etching rate of Fe-Cr allows with Cr percentage. To obtain such a strong decrease, the model consider that Fe or Cr sites, if they are surrounded by Cr or Fe sites respectively, are harder to etch in this case.

Keywords
steel etching; plasma diagnostics; modeling; chlorine plasma; Fe-Cr alloys