Models for Spatial Non-uniformity in Plasma Etching

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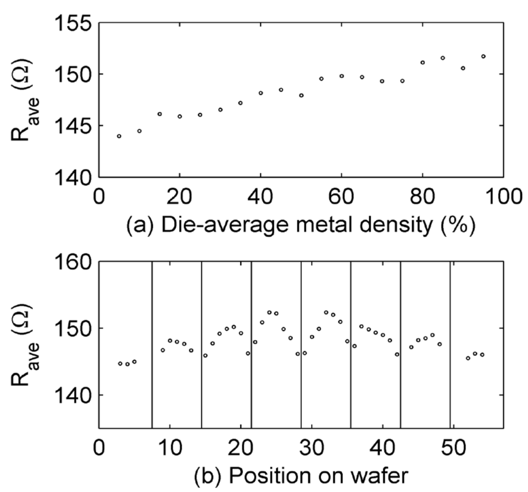
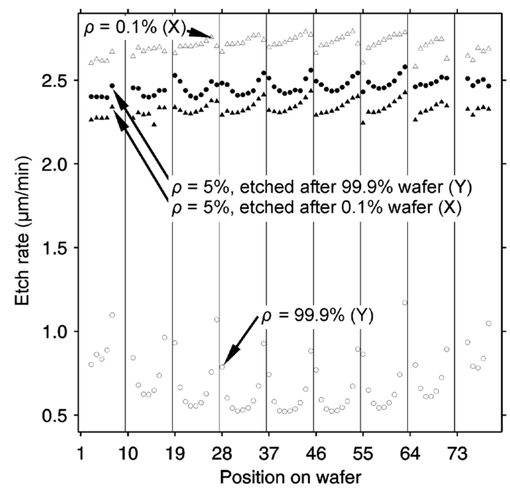
We are studying the plasma etching of aluminum films for IC metallization. Using electrical resistance measurements from a dedicated metal test pattern, we have identified, in a commercially-used etching process, resistance variations of 5% cross-wafer and additionally of about 5% according to the locally averaged metal pattern density (Figure 1). The etching rate also depends appreciably upon the size of the etched feature.

The deep reactive ion etching (DRIE) of silicon for MEMS also experiences spatial non-uniformity, which can be detrimental to its applications. We hope to use our model to predict the uniformity of proposed new operating "recipes." We continue to investigate an observed "memory" effect in DRIE chambers (Figure 2), whereby the average pattern density of one etched wafer influences the rate and uniformity of the subsequent wafer's etching.



▲ Figure 1: Spatial variation of the electrical resistances of aluminum snake patterns etched from a film on a 200 mm-diameter wafer. (a) shows how the average resistance of a snake (R_{ave}) increases by ~5% as the areal density of unetched metal near the feature increases from 5% to 95%. In areas of higher unetched metal density, local competition for reactants is less acute during etching, so that lateral etching of snake features can progress more quickly, increasing the features' resistances. (b) shows a cross-wafer variation of ~5% among the resistances of features with identical local surroundings.



▲ Figure 2: Vertical silicon etch rate as a function of location on each of four etched 150 mm-diameter wafers in a deep reactive ion etch (DRIE) process. A monitor wafer with 5% mask-opening density etched immediately after wafer Y (with 99.9% pattern density) etched consistently faster and less uniformly than a 5%-density monitor wafer etched after wafer X (with 0.1% pattern density). Here and in Figure 1b, the position axis corresponds to locations on a square grid, with each row of locations plotted consecutively and separated by vertical bars on the graph.