Effect on aspect ratio dependence on etch rate: experiment and modeling

Lingkuan Meng
Institute of Microelectronics, Chinese Academy of Sciences, Beijing 100029, P. R. China

As the evolution of 3D IC technology, TSV (Through Silicon Via) etch has been gaining more and more attention in recent years. One of the most important concerns for TSV etch is the in-hole etch rate, which could directly indicate an equipment's capability.

It is generally accepted that for small size, large aspect ratio holes, Bosch process is the recipe of best choice in 3D IC fabrication. The Bosch process's etch rate is a combination result from radicals, plasma density, hardware and time constant. Changing the variables in a Bosch recipe can tune up or down the etch rate, as well as change via or trench profile.

Etch rate is closely related to the pattern geometry, aspect ratio and process parameters, e.g. source power, bias power, gas pressure, gas flow and the switching time at etching and passivation steps. Aspect ratio dependent effect is often seen in the RIE process that etch rate of narrower trenches or smaller diameter holes is slower than that of wider trencher or larger diameter holes even for the same recipe and same hardware setting,.

In this paper, TSV etch is conducted on an AMEC TSV200E chamber with Bosch process by capacitively coupled plasma equipment, for 3um~50um, aspect ratio 1:1~10:1 via holes. It is to establish a numeric relationship between depth and CD, accordingly etch rate. At a smaller CD 3~5um, etch rate linearly increases with CD. However, as CD continues to increase, to a transition point 10um where relation between etch rate and CD shows a nonlinear characteristic. On the other hand, at the same hole, etch depth also presents similar nonlinear trend with cycle times, which is attributed to incident flux difference of neutral. Lastly, author presents a simple model to illustrate etch rate influence on the aspect ratio based on Langmuir adsorption kinetics that accounts for the interaction between ion and neutral flux in deep hole.