Radical flux modeling and analysis for sticking coefficient evaluation.

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1. Introduction

In plasma processes kinetic data for radicals is the most crucial ingredient for predictive simulation. The most neglected area in this regard is the lack of fundamental data for gas-surface or plasma-surface interactions – radical sticking coefficient (SC - depends on material surface). Since *ab-initio* approach to surface interaction requires too heavy computer resources, the experimental validation assisted by computational analysis is not only cost-effective but also indispensable for finding out the principal reaction mechanism [1].

2. Radical flux modeling and analysis

Using parallel plate structure (PAPE) [2] with ArF photoresist on the bottom wafer schematically shown on Fig. 1 we have performed photoresist etching by H_2 plasma in a ICP etch reactor. PAPE structure allows to investigate the effect of radicals (separately) on the surface reaction.

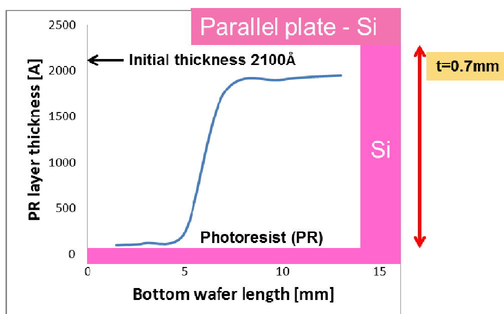

Fig. 1 PAPE structure and ArF thickness profile after plasma etching.

Photoresist thickness profile after etching is shown on Fig. 1. Using Monte Carlo approach we have performed simulation of radical behavior in the same setup. We obtained matching radical stuck profile when sticking coefficient was set to 0.2. Simulation showed that 6% out of simulated radicals (10^6) didn't enter PAPE, 45% radicals stuck on the bottom wafer and only 1% stuck on parallel plate. Remained 48% radicals left PAPE.

3. Conclusions

ArF photoresist layer is fully etched on the exposed area of the substrate whereas under parallel plate there is little etching. Etching under parallel plate is mainly possible due to radical multiple bouncing (re-emission) thus strictly depends on SC of the bottom wafer. The total radical incoming flux on a surface point *i* (Fig. 2) can be written as the summation of the direct radical flux plus all the contributions due to re-emissions of the surrounding points *j*:

$$\Gamma_{radical,i} = \Gamma_{direct,i} + \sum_{j \neq i} (1 - SC_j) g_{ij} \Gamma_{radical,j} \quad (1)$$

where: $\Gamma_{direct,i}$ is the direct flux arriving from the source at the point *i* (0 for top plate) and g_{ij} is the form factor that accounts for how much of the re-emitted flux from the point *j* arrives at the point *i*. The form factor depends on the surface geometry and the re-emission angular distribution [3, 4].

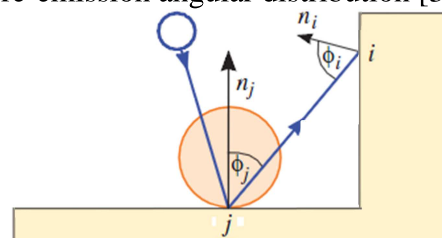

Fig. 2. Radical re-emission [3].

References

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