Decoration of Microdefects in Monocrystalline Silicon: A Theoretical and Experimental Study

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Identification of microdefect distribution in a monocrystalline silicon wafer is key to quality control as well as process development. The microdefect-decoration is accomplished by saturating the silicon wafer with copper at a high temperature followed by copper precipitate growth through rapid cooling followed by surface polishing and subsequent decorating etching.

The microdefect field consists of etch-pits (valleys) formed by the difference in the etching rates of the copper precipitates and the etching rate of the surrounding defect-free silicon. Etching is a three-phase process that involves, transport of reagents from the bulk-liquid phase to the solid surface through a stagnant *mass-transport film*, surface reactions and transport of products back to the bulk-liquid, in that order. In this work it is argued that the macro-decoration of microdefects is typically realized in the absence of significant effect of the liquid-phase diffusion of reactants.

The competing effects of kinetics towards the microdefect-decoration and liquid-phase transport towards surface smoothening are quantified by theoretically derived closed form solutions for the *decorating efficiency* and the *microdefect-polishing efficiency*. Auto-erosion of the microdefects by mildly polishing etchants is also quantified. Closed form solutions for the microdefect-decorating and microdefect-polishing conditions are presented.

Potentially decorating and polishing etchants can be classified based on their dependence on the reactor hydrodynamics. The decorating etchants show a weak dependence on the hydrodynamics in the reactor whereas the polishing etchants show a strong dependence on the reactor hydrodynamics. The surface irregularities are preserved in a decorating etchant whereas a polishing etchant erases the surface irregularities.

The proposed theories are verified by experimental data.

References:

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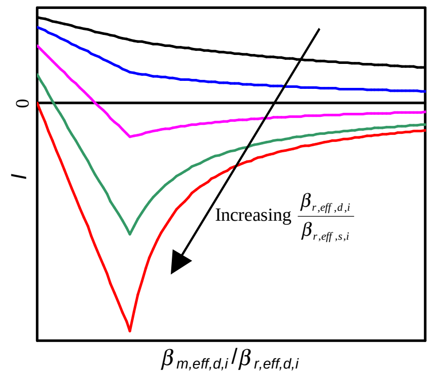

Figure 1. Effect of the mass-transport-film thickness on the decorating efficiency for a given pit depth and $\xi_{s,i}/\xi_{d,i}$.

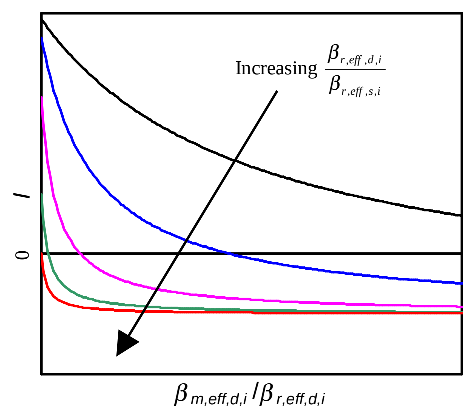

Figure 2. Effect of the effective diffusivity on the decorating efficiency for a given pit depth, mass-transport film thickness and $\xi_{s,i}/\xi_{d,i}$.

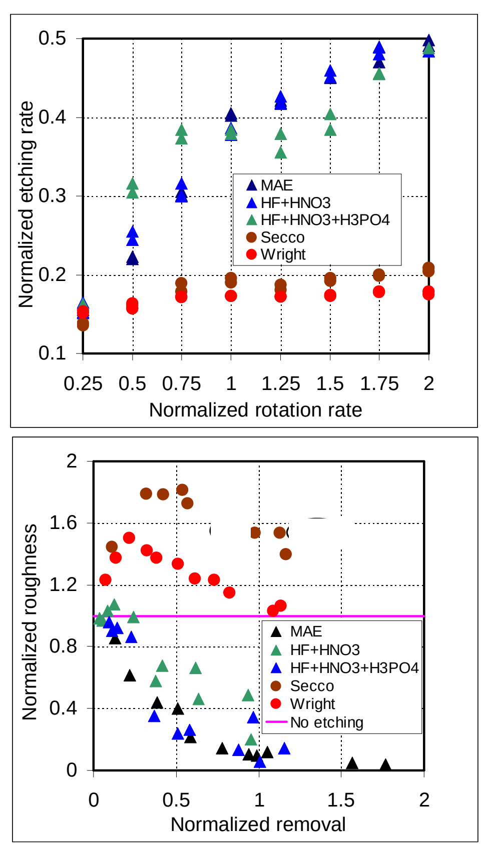

Figure 3. Dependence of decorating and polishingetchants on reactor hydrodynamics