Cleaning Surfaces from Nanoparticles with Polymer Film: Impact of Polymer Removal Conditions

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1. Introduction

In order to keep a high yield during integrated circuits production, a continuous improvement has been carried out in the particles cleaning area, switching from brushes and acoustic cleans to high velocity sprays. Moreover, as typical dimension of microelectronic circuit are getting smaller and smaller, tinier and tinier particles have to be removed (Figure 1). Even though the adhesion and removal of particles on solid surfaces have been studied and documented for years, the integrated circuits industry still misses robust solutions to clean nanoparticles, keeping finest transistors features integrity, and extremely low material consumption [1].

Recently, it has been shown that new processes involving non-Newtonian fluid enable an excellent nanoparticles removal without features damage [2]. In this process, a thin layer of a well-chosen polymer is deposited on the nanoparticles contaminated wafer. Then, the polymer is removed either by peeling or by an extensional flow. To understand the remarkable ability of polymer to remove nanoparticles, two mechanisms are postulated. In the peeling process, the removal capacity is based on a better adhesion between the particles and the polymer rather than between the particles and the surface [2]. In the extensional flow system, the polymer is kept in a liquid state and removed by a siphoning action and the particles are withdrawn from the surface thanks to the fluid viscoelastic properties [3]. Even though they are quite convincing, these two mechanisms still need to be validated by experimental studies in particular when the polymer used to remove the nanoparticles is not truly a liquid or a solid but a viscoelastic liquid exhibiting a complex rheology.

2. Experimental

Silicon wafers of 300 mm diameter are intentionally contaminated by 60nm silica particles. Then, they are coated with a polymer layer. This latter is spray stripped with a chemical solution and the cleaning efficiency of the process is quantified by counting nanoparticles before and after the complete polymer removal step thanks to a KLA Surfscan SP3 blue laser diffraction tool.

3. Results & Discussion

In our work, the polymer layer is removed using a spray dispense with centrifugation rather than siphoning. This process enables a high particle removal efficiency up to 90 % in average. However, the efficiency is not homogeneous: as can be seen in Table 1, the particles removal efficiency is very high far from the spray injection while a lower efficiency is observed in the vicinity of the spray injection.

To understand these observations, we focus on the influence of wafer centrifugation and viscoelastic properties of the polymer layer. By writing a stress balance on the polymer layer, we have been able to establish a correlation between the viscoelastic properties of the polymer, measured thanks to a cone-plan rheometer, and the centrifugal force, which exert an external force on the polymer layer.

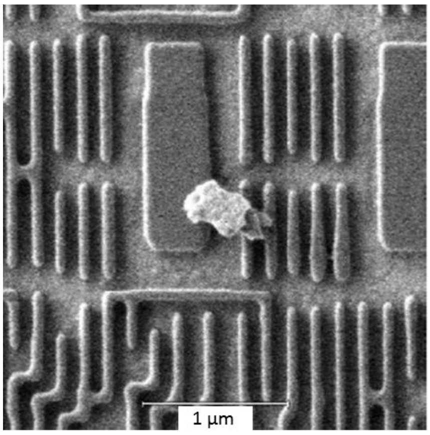


Figure 1: Particle on a patterned surface

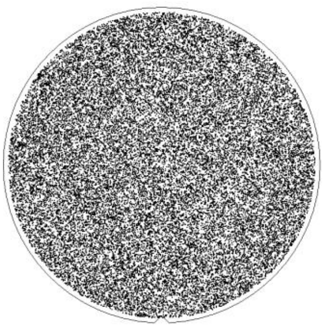
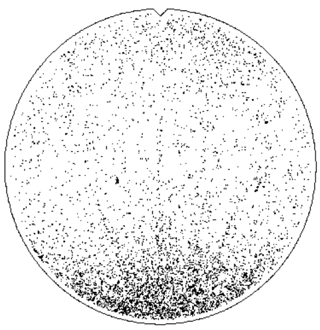
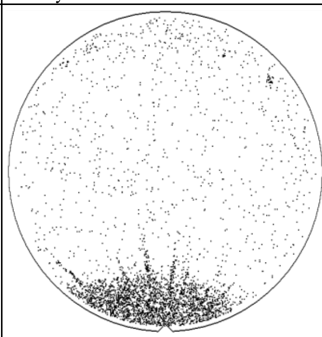
	Initial Contamination	Post Process Polymer A	Post Process Polymer B
Mapping Defects > 30nm			
Removal Efficiency		82 %	90 %

Table 1: Efficiency of the cleaning process depending on the polymer layer

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