IMMobilization of DNA on CMOS Compatible Materials


1. INTRODUCTION

DNA chips currently are developed using glass, plastic or ceramic substrates. We focus the present work on the immobilization of DNA on CMOS compatible materials, which is the first and crucial step for the construction of microarrays; silicon oxides like thermal oxidation of silicon, used for field isolation oxides, and silicon oxide deposition by PECVD, used for interlevel dielectrics, or by Pyrox, used for final passivation; and aluminum, still the major material for making the electrical interconnections and contacts in CMOS circuits.

Three methods of formation of self-assembled layer on silicon oxide and aluminum were investigated. The two first methods, aldehydey process, with trichlorosilane or trimethoxysilane, and the third method, called aminated process, (APTES). Cy3- and biotin labeled DNA was sintetized and immobilized on the surface of the chips. Detection was done using a fluorescent confocal scanner.

2. RESULTS AND DISCUSSION

a) Dry-wet-dry thermal and pyrox oxides, were silanized with the trichlorosilane and compared with the glass slide. Thermal silicon oxide allows the binding of two fold more aminated-DNA than pyrox silicon oxide (fig. 1), aluminum was degraded during the process due to the HCL formation (fig. 2).

b) Silanization with the aminated process. Attachment of the aldehydey oligomers were not stable, due to the imine groups formed, they are removed with the washing step (fig. 3), and those must be reduced into stable amines by borohydride treatment.

c) All materials allow the binding of aminated DNA with trimethoxysilane. Wet silicon oxide shows results similar to glass slide (fig. 4) and is better than the other silicon oxides, PECVD binding more, then, dry oxide. Aminated DNA could bind on surface of aluminum too (Fig.4E), but less than in silicon oxide. Aluminum was not degraded at all by the trimethoxysilane process.

3. CONCLUSION

DNA immobilization has been achieved on CMOS compatible materials: wet, dry, Pyrox, PECVD oxides and aluminum. Wet oxide showing more DNA binding, followed by Pyrox, PECVD and dry oxide successively. This can be explained as a function of OH- radicals that are present during the wet oxidation, so that a higher concentration of Si-OH groups could be left at the surface by the reaction H2O + Si-O-Si = Si-OH + Si-OH, yielding more DNA acceptor endings. PECVD and Pyrex methods also lack OH groups during the deposition like dry oxidation, but the water vapor being formed during the gases reaction might react with the silicon oxide to create surface Si-OH groups but with lower probability due to the short time left at the end of the process for this to happen and the lower temperature used in both processes. Pyrox being more susceptible due to its higher porosity.

In conclusion, DNA binding on wet silicon oxide with aldehyde trimethoxysilane process appears as the optimal combination, equivalent to binding on glass and fully compatible with standard microelectronics CMOS fabrication.

Publication: