Surface Conditioning

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The surface cleaning operations both wet and dry discussed in notes SN-17 and SN-18 respectively do not only remove chemical contaminants and particles from semiconductor surface, but also leave it in certain chemical condition depending on the cleaning chemistry used. In the case of wet chemistries an important role is also played by the aggressiveness of the DI water rinsing process employed. Overall, specific chemical makeup of semiconductor surface is a byproduct of the cleaning/rinsing process. An understanding of the correlation between composition of cleaning ambient and resulting chemical composition of the surface allows us to vary surface properties in the controlled fashion and is a foundation of the surface "conditioning" technology.

In the process of "surface conditioning" used to alter in the controlled fashion chemical condition of the semiconductor surface most often the goal is stabilize the surface, i.e. to create conditions preventing any further chemical reactions on the surface and, by doing so, to improve reproducibility of surface characteristics.

Figure 1a shows much simplified diagram of a "clean" Si surface, i.e. the surface free from particles and metallic contaminants, but inevitably covered with typically about 1 nm thick layer of spontaneously grown SiO_x containing Si-H and Si-OH groups resulting from the cleaning/rinsing processes as well as organic contaminants from the ambient. Such surface remains chemically active which means that it will undergo modifications of its chemical make up that will depend upon ambient in which wafers are stored and time of exposure.

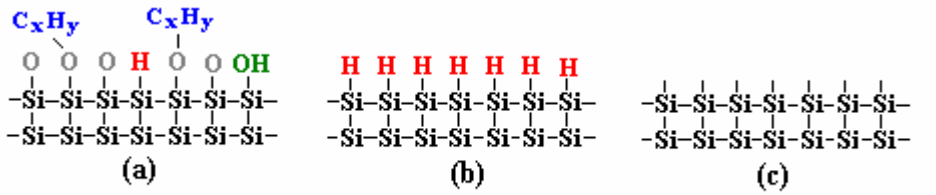

Fig. 1

One way to condition such surface toward chemical passivity and resulting reproducibility of its characteristics is to assure saturation of Si bonds on the surface with hydrogen by careful treatment in HF:H_2O solution. Resulting hydrogen termination of the surface (Fig. 1b) prevents, due to the strength of Si-H bond, its uncontrolled oxidation. The "hydrogen cap" can be readily removed (Fig. 1c) immediately prior to subsequent critical deposition step such as epitaxial deposition of Si or SiGe layer.

Several other examples of surface conditioning procedures can be given. In each case chemistry of the surface conditioning process is determined by the needs of the subsequent operation, e.g. requirements regarding chemical make up of the surface prior to gate oxide formation and contact deposition are very different. Incidentally, the deposition steps are not the only ones that typically require some kind of surface pre-treatment applied in addition to cleaning. For instance, prior to oxide etching using anhydrous HF/methanol vapor, oxide surface must be subjected to moisture removing treatment in order to assure reproducible initiation of the etch reaction.