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Using pH to Control the Hydrophobic or Hydrophilic Character of Silicon Wafers

AWARDS:

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Throughout manufacturing industries, often in semiconductor production, various silanes are used to functionalize silanol on the surface of a silicon wafer. Certain steps of the manufacturing process require a hydrophobic or hydrophilic characteristic; this can be an expensive and time-consuming process. Can pH be used control the hydrophobic or hydrophilic character of silicon wafers?

Hypothesis: If we coat the wafer with N-(6-aminohexyl)aminopropyltrimethoxysilane (AAS), we can increase the hydrophobic character of the wafer by applying an acid (low pH), or revert it back to more hydrophilic by adding a base (high pH).

Procedure: Four trials were conducted, and in each trial, four treatments were tested: Control="No Coating", "Coated but not treated," "Acid treated," "Base treated." A water droplet was placed on the silicon wafer through a micropipette, and the contact angle (°) was measured and recorded. Then, the wafer was coated with AAS and the same procedure was done. The wafer was then immersed in acid for 5 minutes and the same procedure was done. Finally, the wafer was immersed in the base solution for 5 minutes and the procedure was repeated.

Results: The highest average contact angle of 56.78° was achieved with the base treatment, followed by "coated but not treated," then "acid treated," then "no coating." The "coated but not treated" yielded similar values (53.37°) to the "base treated" (56.78°). Adding acid to the "coated but not treated" decreased the average contact angle by 13.60% from "coated but not treated"and then adding base increased the angle by 23.14% from the "acid treated." Although "no coating" and "coated but not treated" were both at pH of 7, the addition of the coating significantly increased the average contact angle (53.37) from no coating (36.51), indicating an increase of hydrophobicity. Coated but not treated was 53.37° ‡’ 100 x |53.37 - 36.51|/36.51 = 46.18% increase from "no coating"

Conclusion: We predicted in our hypothesis that we can change the hydrophobic or hydrophilic character of the silicon wafer by applying a base (high pH) or an acid (low pH) to the AAS-coated surface. The results thoroughly demonstrate those characteristics; first, note that coating the control group ("not coated" wafer) with AAS initially increases the average contact angle from 36.51° to 53.37° (seen in the "coated but not treated" group), thereby increasing hydrophobicity as anticipated in our background. For the untreated and uncoated wafers, pH was recorded to a default value of 7. Once we applied the 5% acetic acid (pH 2.4) to the coated wafer, the average contact angle decreased to 46.11°, indicating lesser hydrophobicity or greater hydrophilicity. Applying the sodium bicarbonate solution (pH 8.5) caused the average contact angle to increase back to 56.78°, reverting the silicon wafer to a more hydrophobic state. Since we only changed whether we apply an acid or a base (i.e. applied pH), it can be concluded that pH can be used to control the contact angle of the silicon wafer surface, thereby controlling the hydrophobicity or hydrophilicity of the silicon wafer surface.