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Surface film thickness of NaOH-treated and silanized silicon wafers

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ABSTRACT Hot sodium hydroxide solution etched the polished surface of silicon wafers as measured by ellipsometry. Subsequent silanization of such etched surface utilizing 11-bromoundecyltrichlorosilane increased film thickness on the wafers. Further treatment with sodium azide for azide substitution of the bromo end group did not significantly change the surface film thickness.

Keywords: Film thickness, ellipsometry, sodium hydroxide, silanization, silicon wafer

Silicon wafers were chemically treated to present surface azido end groups as reported in the literature.[1] Pieces of about 11x13 mm were first cut from silicon wafers disks (single side polished, N-type, no dopant, 2 inches diameter, 0.5 mm thick). The functionalization process began by treating the wafer pieces with 0.1 M NaOH for 3 min while heating at 80 °C with frequent stirring. This alkaline treatment significantly decreased the original film thickness of the polished side on the wafers by 26.8 % (Figure 1) as measured by the J.A. Woollam Co. alpha-SE Spectroscopic Ellipsometer. Data were collected at an angle of 70° and fitted to the Si with transparent film model. This decrease in film thickness points to surface etching on the wafer.

A remark of the alkaline treatment is that freshly cut wafers will expose pure Si which can react with water under alkaline conditions.[2] As a result, the wafer surface can become contaminated increasing surface roughness. With freshly cut wafers, it is recommended to decrease the alkaline treatment time to 1 min. If gas bubbles start to emerge from the wafers during the alkaline treatment, immediately initiate the rinsing steps to minimize damages to the surface of the wafers.

The NaOH-treated wafers were then silanized in 3 µL/mL of 11-bromoundecyltrichlorosilane in toluene for 30 min at 80 °C and frequent stirring. Wafers were then rinsed and cured for 10 min at 110 °C. After silanization, the surface film thickness increased by 1.07 nm (Figure 1). This supports a successful surface functionalization.

Further reaction of the functionalized wafer with 5 mg/mL of sodium azide in N,N-dimethylformamide for 1 h at 80 °C with frequent stirring had no significant effect on surface film thickness (Figure 1).

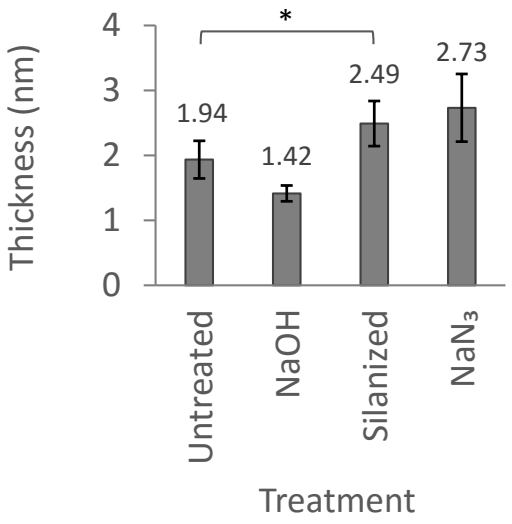

Figure 1 Average surface film thickness of silicon wafers upon consecutive chemical treatments in the order shown above. *Significant different, one-way ANOVA and Tukey's HSD test, $p < 0.05$, $n = 26$. Error bars are the standard deviations.

Literature

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