

Depth Profiling of Aluminium Diffused in Silicon by Activation Analysis with 14 MeV Neutrons

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ABSTRACT

Here the technique of Activation analysis with 14MeV neutrons was used to know the depth profile of Aluminium in samples of p-type Silicon rubbed with Alumina and baked at high temperature(800°C). Chemical etching was done to remove layers and find the depth.

Key words: Semiconductors, Silicon, Aluminium, Depth profile,.
14 MeV neutrons; Activation analysis.

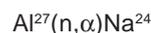
INTRODUCTION

Diffusion of silicon with Aluminium is normally carried out to control electrical characteristics of silicon and also to manufacture semiconductor devices. It is known that different grain size alumina powders are used to polish crystalline silicon to meet experimental requirements. It may be possible that during polishing, aluminium atoms get diffused in silicon. However, so far no attention has been paid to study this diffusion and the depth profile of Aluminium in Silicon. The diffusion of aluminium in Silicon, at 800°C was analysed using 14 MeV neutron activation analysis.

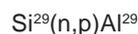
MATERIAL AND METHODS

A silicon wafer (p-type) was rubbed for 2 hours with fine alumina powder (grain size in nanometers). The wafer was chemically cleaned and cut into pieces of dimensions 1cm². Some of these samples were baked at 800°C in nitrogen atmosphere for a period of two hours. The Silicon sample rubbed with Alumina and the baked silicon samples rubbed with Alumina were exposed one

by one to 14 MeV neutrons⁴⁻⁷ for an hour to induce the following nuclear reactions:



With $t_{1/2}=14.96$ hours, $E_{\gamma}=1.369$ MeV(100%), 2.73 MeV(100%) and



With $t_{1/2}=6.6$ minutes, $E_{\gamma}=1.28$ MeV(100%)

To avoid interference due to the gamma-ray emitted by other radioisotopes a cooling time of 30 minutes was given. The activity of energy 1.36 MeV was measured by a NaI(Tl) detector for 30 minutes was stored in the computer based MCA. Later on the silicon sample was etched in a HF solution, as the silicon wafer when stored for any length of time will often get covered by a top 50 Å° of oxide layer and this layer is removed using a short (about 40-60sec) etch consisting of HF:H₂O::1:50 by volume whose etch rate is 70Å° / minute[1] or can also be chemically polished in HF:HNO₃ ::2:5 (etch rate of 20µm)². By controlling the etch rate, 0.1µm surface layer³ of the silicon

was removed. The activity of the Aluminium was then measured. This activity was subtracted from the earlier measured activity which gave the net activity due to aluminium atoms present in the first $0.1\mu\text{m}$ of the sample. After removing $0.1\mu\text{m}$ of the silicon layer each time the γ activity was measured and the experiment was repeated. Standard corrections for the half-life, background subtraction etc. were made and the results obtained.

RESULTS AND DISCUSSION

The results obtained from the activation analysis are shown in Figure 1 and 2. Figure 1 shows results for silicon samples which were mechanically rubbed with Alumina and activated to know the amount of aluminium in different layers after etching for three samples which were all irradiated for one hour. The results show Aluminium to be on the

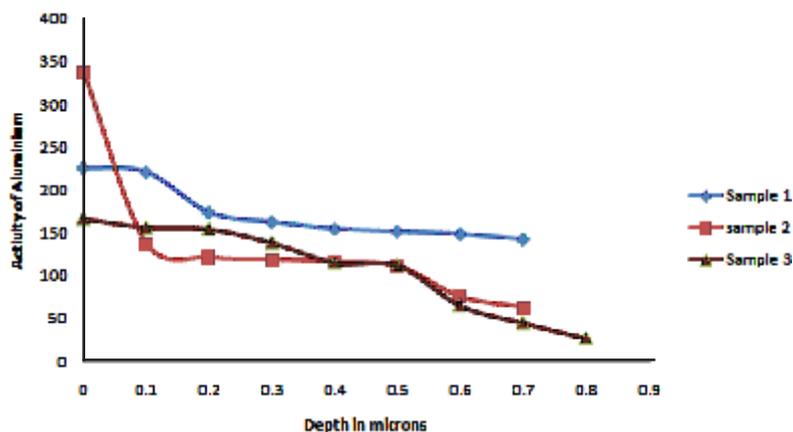


Fig. 1: Depth profile of Al in Alumina rubbed on silicon

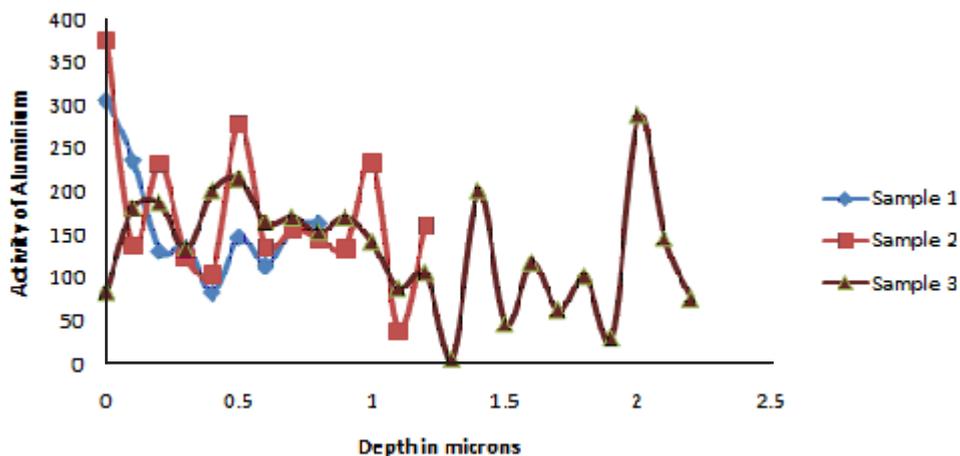


Fig. 2: Depth profile of Al in baked silicon sample

surface and less in the bulk. Figure 2 shows result for silicon samples which were not only rubbed with alumina but also baked at a high temperature in an oven kept at 800°C . Here the Aluminium has diffused from the surface to the bulk of the sample.

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