ANISOTROPIC ETCHING IN DIFFERENTS TEMPERATURES USING KOH SOLUTION AND PROTECTION OF SI_3N_4

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Abstract **- The main objective of the present work is show variation of the anisotropic etching rate of the Si <100> wafers single-crystalline, P type with 1-10 Ω.cm resistivity and a top protection of Si_3N_4 in reaction with 27 wt.% KOH/water solution. Etch rate agree with Arrhenius Law.**

Index Terms **– Anisotropic etching, Arrhenius Law, KOH Solution, Si_3N_4.**

I. Introduction

SILICON micromachining is used for the fabrication of three-dimensional microstructures on silicon wafers. Wet chemical etching of silicon are used KOH or TMAH (tetra-methil-ammonium hydroxide) solutions of varyng composition and temperature.

In this work was used KOH solution. This solution show high anisotropy, easy handling and is disposable [1].

The wafer with Si_3N_4 was choosed by the Si_3N_4 be a perfect material for the protection against anisotropic etching. The Si_3N_4 has a low etch rate compared with silicon when in KOH solution. Anisotropic etching rate is represented by the classical Arrhenius Law:

$$R=R_0.Exp(-Ea/KT) \quad (1)$$

Where: R_0 – preexponential term; Ea – activation energy; K – Boltzman constant (8,617E-5 eV/K) and T – temperature of the solution in Kelvin.

II. Anisotropic Etching

The anisotropic reaction in KOH solution dissolve Si preferably in one or two crystallographic directions. This erosion usually has its smallest speed in the <111> direction resulting in the exibition of the {111} planes. The smaller erosion speed experienced by the plans in the <111> direction has been associated with the number of available free conections on the silicon surface [2].

III. Experiments

The solution was prepared with 426,42 g of KOH in 1L of water. The four samples with geometrics pattern defined by lithography were clean with propanone, isopropilic and water for removal of the photoresist, subsenquently were placed in the vertical position in the chemical reactor containing KOH solution. Each sample remains one hour at a fixed temperature. The process was controled by a thermostatic baths with a variation of ± 0,5ºC. The results obtained were verified through of a optic microscope with resolution 600x and Eletronics Confocal microscope. The averages of results are in the Tab. 1. The Tab. 1 compare experimental etch rate (R_{Exp}) with theoretical etch rate determined by the Arrhenius law.

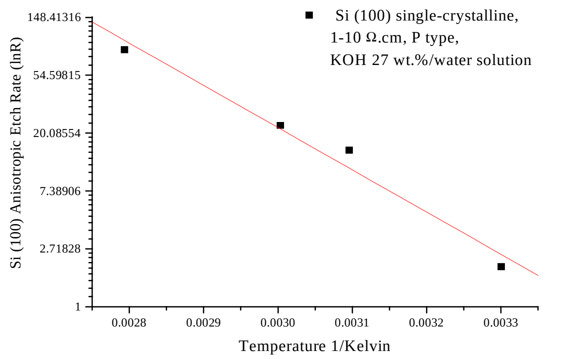

Fig. 1. Diagram of Arrhenius of the anisotropic etching rate Si wafer (100) with KOH 27 wt.%.

Tab 1. Etching rate and activation energy at a fixed temperature.

T (ºC)	R_{Exp}	R_{Teo}	Ea
30	2 µm	2,5 µm	6,2E-1
50	15 µm	10,9 µm	6,2E-1
60	23 µm	21,5 µm	6,2E-1
85	85 µm	99,4 µm	6,2E-1

We observe variation of etch rate with temperature conform figure 1.

IV. Analisys of the Microstructures after Anisotropic Etching

The scanning electronics microscope (SEM) allow a detailed visualization of the microstructures. Microstructures visualized after anisotropic etching showed cavity (figure 2a) with defined diaphragma (figure2b). This confirm the high anisotropy of echting. The cavity can wall well defined and deep with little defect (figure2c). The defect of surface probable come

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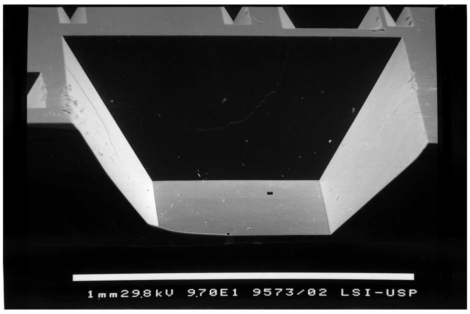
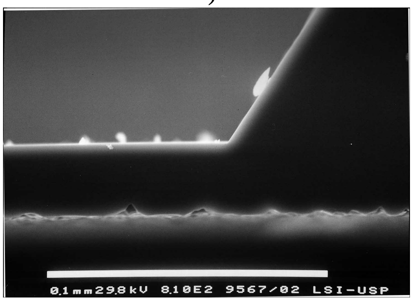
out by the defect of crystal of silicon of the substrate used.



a)



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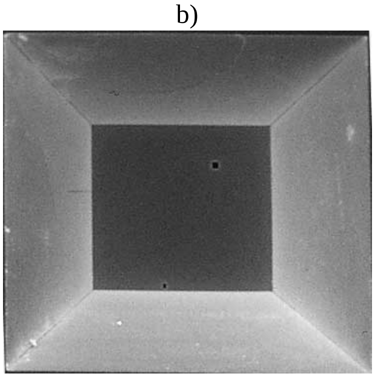

c)

Fig. 2 a), b) and c) SEM photographs of the surface etched for 3 hours at 85 °C and concentration of 27% wt KOH

V. CONCLUSION

The temperature and concentration of the solution define anisotropic etching rate. So for each concentration there is a determined activation energy (Ea) and a determined preexponential factor that substitute in the expression (1) allow the calculation of the rate for fixed concentrations and temperatures.

Compared the results obtained in the experiments with the date provided by Seidel et al [3]. Conclude that results were satisfactory.

VI. REFERENCES

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