Statistical Analysis study different between wet and dry etching

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Abstract

In this paper a statistical analysis was studied, the different between wet and dry etching was analysis by using Chi-Square distribution. The statically result show that dry processes have etch rates with anisotropic etching more than wet etching process .These results were agree with published data and researches results.

Key word: Wet etching ,Dry etching,Statistical analysis

دراسة الاختلاف بين الحفر الجاف والرطب باستخدام الاحصاء التحليلي

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الخلاصة

تم في هذا البحث دراسة الاختلاف بين تقنيات الحفر الجاف والرطب بأعتماد الاحصاء التحليلي بأستخدام توزيع كاي (أختبار يتعلق بالنسب لتوزيع متعدد الحدود). لقد بينت النتائج الاحصائية أن تقنية الحفر الجاف تمتلك معدلات حفر مع نوعية حفر غير موحد الخواص أكثر بكثير من تقنية الحفر الرطب . وقد جاءت هذه النتائج متوافقة مع البيانات والبحوث المنشورة .

كلمات افتتاحية :الحفر الرطب ،الحفر الجاف / الاحصاء التحليلي.

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Introduction

The rapid development of plasma etching technology was stimulated by its application to the manufacture of microelectronic devices .Today , state of the art integrated circuit manufacture depends on the mass replication of tightly controlled , micron- sized features in a variety of materials. Plasma etching has become central to this process because it is the only current technology that can be achieved efficiently and with high yield. [1]

There are several benefits of plasma etching , compared to wet etching using acid . The handling of dangerous acids and solvents is eliminated in plasma etching . Only small amounts of chemicals are needed automation is also . [6] In order to form a functional MEMS structure on a substrate , it is necessary to etch the thin films previously deposited and/or the substrate itself. In general, there are two classes of etching processes:

- Wet etching where the material is dissolved when immersed in a chemical solution.
- Dry etching where the material surface is sputtered or dissolved using reactive ions or a vapor phase etchant . [7]

Bulk Silicon Micromachining

bulk micromachining is one of the micromachining technologies that are used to fabricate MEMS (Microelectronic Mechanical Systems) structures. Micromachining is the technique used to sculpt or machine silicon on a microelectronic scale. In bulk micromachining , structures are shaped by etching a large single crystal substrate. [3] The two types of etches that are associated with bulk micromachining are isotropic etch and anisotropicetch.Each type of etching is defined by their selectivity, or the way that the material in the substrate are etched away, and the type of etchant used.[3] Wet etching the simplest etching technology. All it requires is a container with a solution that will dissolve the material in question. Unfortunately , there are complications since usually a mask is desired to selectively etch the material . First we have to a mask that will not dissolve or at least etches much slower than the material to be patterned. Secondly , some single crystal materials , such as silicon, exhibit anisotropic etching in certain chemicals .Anisotropic etching in contrast to isotropic etching means different etches rates in different directions in the material. [7]

The dry etching technology can split in three separate classes called reactive ion etching(RIE), sputter etching ,and vapor phase etching . In RIE , the substrate is placed inside a reactor in which several gases are introduced . Plasma is struck in the gas mixture using an Dc ,RF power source , breaking the gas molecules into ions . The ions are accelerated towards, and react at the surface of the material being etched, forming another gaseous material .

This is known as the chemical part of reactive ion etching . There is also a physical part which is similar in nature to the sputtering deposition process. If the ions have high enough energy, they can knock atoms out of the material to be etched without a chemical.

It is a very complex task to develop dry etches process that balance chemical and physical etching, since there are many parameters to adjust .

By changing the balance it is possible to influence the anisotropy of the etching , since the chemical part is isotropic and the physical part highly anisotropic the combination can form sidewalls that have shapes form rounded to vertical.[7]

In this paper we used (A chi-square distribution – test of concerning the equality of several variances), and this test is called Bartlett’s test . The following section shows this test in more detail.[2]

Bartlett’s test is containing many steps as:-

1. Formulation of the null and alternative hypothesis.
2. Analysis of variance table

Sample	**Degrees of freedom (d.f) (n_i-1)**	**Difference of sample S^2_i**	**Sum of squares $SS_i = (n_i - 1) S^2_i$**	**Log S^2_i**	**(n_i -1) log S^2_i**	**1 / (n_i -1)**
1	n_1 -1	S^2_1	SS_1	Log S^2_1	(n_1 -1) log S^2_1	1 / (n_1 -1)
2	n_2 -1	S^2_2	SS_2	Log S^2_2	(n_2 -1) log S^2_2	1/ (n_2 – 1)
K= Total	Σ (n_i -1)= N –K		Σ (n_i – 1) S^2 Σ SS_i		Σ(n_i -1) log S^2_i	1 / (n_i -1)

$$S^2_p = \Sigma (n_i-1) S^2/N-K = \Sigma SS_i /N-K \quad \text{--------------1}$$

$$b = 2.3026 (M /C) \quad \text{--------------2}$$

$$M = (N-K) \log S^2_p - (n_i -1) \log S^2_i \quad \text{--------------3}$$

$$C = 1+1/3 (K-1)[\Sigma (1/ (n_i -1) -1 /N - K] \quad \text{-----------4}$$

$$S^2_i = [y^2_i - (y^2_i/n_i)] /n_i -1 \quad \text{------------5}$$

Application and Discussion

If operation experiments proving that by using plasma etching technology we obtain on etch rates more than wet etching technology and to prove that theoretically , we used Bartlett's test.

To analysis the results we have to start with:

- Formulation of the null and alternative hypothesis

  H : There is different between etching technologies.

  H_1: There isn't different between etching technologies.

- Test – Statistic

Etching Technology	
Wet etching sample 1	Dry etching sample 2
Etch Rate	
0	272.33
272.33	544.66
544.66	816.9934
	1089.32
	1361.65
	2178.6

From: - α= 0.05 , V= K-1 , K=2 , N= 9

The refuse region: $B > X^2_{\alpha,\, v\ (Tabulated)} = X^2_{0.05,\, 1} = 3.84146$

- Analysis of Variance Table to etching technology

Sample	$(n_i - 1)$	S^2_i	$SS_i = (n_i - 1) S^2_i$	$\log S^2_i$	$(n_i - 1) \log S^2_i$	$1 / (n_i - 1)$
1	2	74163.6282	148327.2578	4.87019	9.74038	0.5
2	5	457323.9145	2286619.5726	5.66022	28.30112	0.2
K = Total	7		2434946.8304		38.041499	0.7

And from: equ.1, 2,3,4,5,

We obtain: M=0.74824, C= 1.1857148, b= 1.453

Where: α: Level of significance

v: Degrees of freedom

SS_i: Total sum of Squares

S^2_i: Difference of Sample

Decision and conclusion

The comparison of the study results show that

b < X^2 Tabulated

Which is accept null hypothesis (**H** : There is different between etching technologies) by using plasma etching technology we obtain an etch rates greater than in wet etching with anisotropic etching that results agree with Richard C.Jaeger [5], Mohamed-el-Gak [4] , Kirk R .Wiliams et al [7], and more other published researches.

Finally plasma etching ,which has number of advantages over wet etching ,falls into three categories ,physical, chemical /physical ,and purely chemically dominated etching. Various etch technologies that use plasma as etchant exist.

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