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THERMALLY EVAPORATED Ni_2Si MASKS FOR OPTICAL DEVICES ON Si

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ABSTRACT

This work presents a suitable fabrication step to obtain deep etched structures on Si using Ni_2Si as mask for alkaline solutions. In particular, V-grooves (60μm deep) and membranes (250μm deep) can be easily fabricated (2h and 8h, respectively), making Ni_2Si an interesting alternative to replace SiO_2 masks. The stoichiometric of the film was investigated by RBS resulting in a constant as Ni: Si=2:1.

1. INTRODUCTION

Because of the high degree of integration of electrical devices (Moore's law) electrical interconnects are reaching their fundamentals bottlenecks in term of speed, packaging, and power dissipation [1]. In spite of the possibility to overtake the bottleneck for several years by improving design and materials performances without changing any present architecture paradigm, optical interconnects becomes more and more appealing not only for computer to- computer (which is yet quite established) but also for onboard and intra-chip connections. Such connections are obtained using conventional Micromachining processes. To implement these connections, there are a lot of materials that can be used as substrates, like $LiNbO_3$ [2], but the popular material to be used is Si. Many efforts have been made to develop suitable processes to micromachined Si, using a variety micromachining processes, such as isotropic and anisotropic etching and deposition processes in order to fabricate membranes (that can be used in integrated optical pressure sensors, for example [3]), splitters and mirrors and to connect optical fibbers to a fabricated multi-layered optical structure, in particular obtained by thin film deposition on Si substrates. For instance, etched V-grooves can be used as a mechanical support for fibbers, which deliver light to a buried waveguide, in the popular endfire coupling [4]. V-grooves are defined by a patterned mask on Si and by a further etching in an alkaline solution, such as KOH [5]. SiO_2, as mask, is somewhat inconvenient for deep etching, since it is consumed by the KOH solution [6]. Other masks were used to avoid such inconveniences but produce other undesirable features like stress due to high processing temperatures involved [6]. This work presents a convenient low temperature process based on Ni_2Si, which proved to be resistant to deep KOH etchings.

2. EXPERIMENTAL SETUP

Thermally evaporated and patterned Ni layers (200nm) were annealed at 250°C for 20 min. At temperatures above this value up 300°C, Ni and Si react in solid phase resulting mainly in Ni_2Si [7]. A subsequent KOH etch (30% wt.) during 2 or 8h was enough to produce V-grooves or membranes, respectively.

3. RESULTS AND DISCUSSIONS

The etching quality can be appreciated in Figure 1. Membranes (250μm) and V- grooves (60μm) were obtained. The V-groove resulted from the large difference in etch rate of the different Si-crystal planes: 100:16:1 for the <100>, <110> and <111> plane, respectively [8].

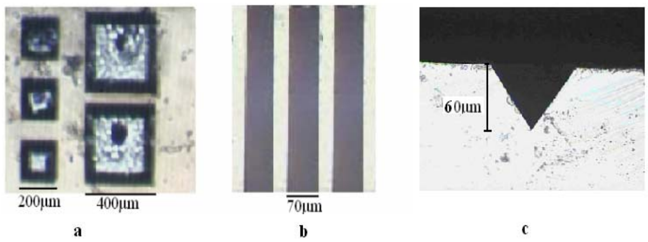

Figure 1 - Results a) membranes, b) top view of V-grooves before Ni removal, c) cross section of V-grooves.

Ni_2Si exhibits excellent adhesion to Si, being almost inert to alkaline mediums. This could be verified by measuring R_{100}/R_{111}= h/h'*sin (θ), where h' is the Si lateral underetch for an etched depth h and θ is the angle between the (100) and (111) planes assuming that mask is not consumed (Fig. 2). An experimental value of 33.1±0.6, compared with 35 from ref [8], which validates such hypothesis, demonstrates the efficiency of Ni_2Si.

Figure 3 shows the RBS spectra of Ni_2Si films formed at 250°C. From the simulation curves of RBS data, the stoichiometric composition of samples maintains a constant as Ni: Si=2:1. For such phase, the significant slope of the left-hand-side of the Ni peak illustrates that the thin film becomes more agglomerated. Consistent with the results reported in previous literatures [9], the channeling yields of Ni in $NiSi_2$ dramatically drop with that of the Si substrate, de-

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monstrating that nickel disilicide on Si (100) is more epitaxial than monosilicides.

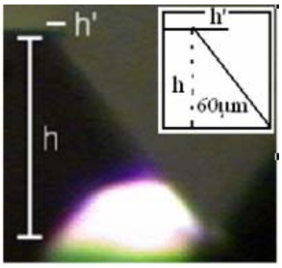

Figure 2 - Si lateral underetch for a etched depth h.

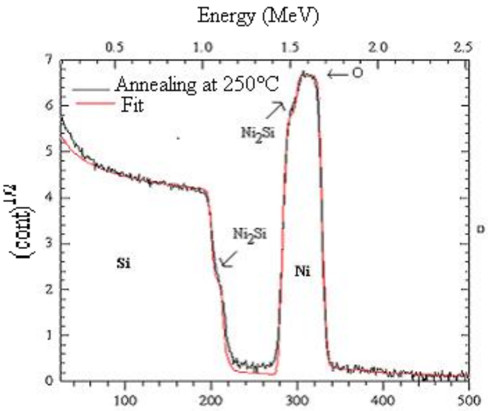

Figure 3 - RBS spectra of Ni_2Si films formed at 250°C. the stoichiometric composition of samples maintains a constant as Ni: Si=2:1

4. CONCLUSIONS

In this work we have demonstrated that micromachining processes, like anisotropic etching, are suitable to fabricate V-grooves and membranes. Other applications of such processes include the fabrication of mirrors and splitters. A novel material to be used for such applications on Si has been studied either. The Ni_2Si has a low formation temperature, good adherence on Si and resistance in alkaline mediums. These properties make it a promising candidate material to be used as mask.

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