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Growth and Characterization of Germanium on Insulator (GOI) from Sputtered Ge by Novel Single and Dual Necking techniques

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1. Introduction

Germanium on Insulator (GOI) structure promises a MOSFET (Metal Oxide Semiconductor Field Effective Transistor) with enhanced performance and reduced leakage current because of the inherent benefits from bulk germanium and SOI structure. GOI substrate fabrication itself is still under active research. A few ways of GOI fabrication are being explored which include: wafer bonding[1] zone melting,[2] condensation[3], Epitaxial growth[4], and, rapid melt growth technique[5]. Zone melting and rapid melt growth use the similar micro crucible technique. Rapid melt growth with necking is the unique technique by which GOI can be fabricated however detailed studies are needed to in several aspects to fabricate the GOI structure in required size on the 8" inch wafers. In this work, investigations were done on the fabrication of GOI and it has been successfully grown below melting temperature using single and dual necking techniques.

2. Experiments

In these experiments, initially a thin 15nm layer of thermal oxide followed by 100 nm of LPCVD nitride were deposited on 8 inch silicon wafer and structures were patterned and etched. Later 100 nm of pure Ge film was deposited by RF sputtering and this was capped with USG oxide. This was again patterned using same mask with some X shift to get Ge on Si for seed window. Adequate Y trims were made to contain the seed layer on top of the nitride layer so that multiple seeding areas were not created by any mis-alignment at lithography. After etching, it was capped with 1000 Å of un-doped silicate glass (USG) to form the crucibles. For dual necking, an additional SiO_2 layer was grown to create second necking and patterned with additional shift as shown fig. 1b. RTA was done at different temperature to study the growth aspects of Ge on Insulator.

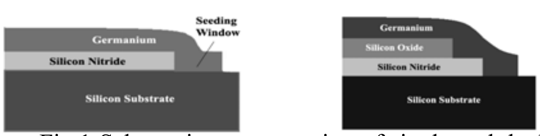

Fig.1 Schematic representation of single and dual necking techniques

Results and Discussion:

Figure 2 (a) - (d) shows the optical micrograph of grown crystals with different temperatures and times. As reported already, we tried the growth at temperatures above melting point (938°C) of Ge. Ge balling up growth was observed due to Ge surface energy which is known as Stranski-Kranstanov growth (Fig.2). Figure 3 shows SEM picture of Ge balls after cap layer etching. The Ge balling up reduced and continuous growth achieved with the reduction of growth temperature as shown Fig.2.

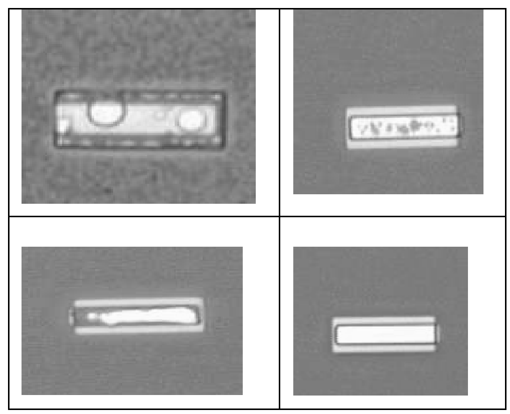

Fig.2 Optical Micrograph 10um pad (a) 940°C at 10 seconds (b) 932°C at 3 seconds (c) 925°C at 10 seconds and (d) 925°C at 5 seconds

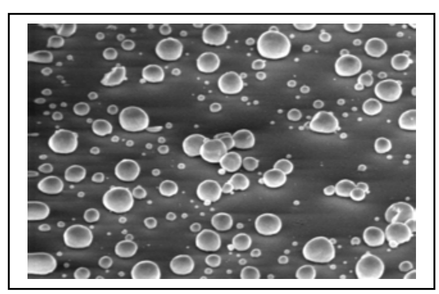

Fig.3 SEM photograph of Ge balls

Growth experiments below the melting point resulted in good crystals. It is basically growth from the semisolid state instead of liquid state yielded good crystals and the interface was quite continuous during growth which is shown in Fig.4. Less Si diffusion is observed for dual necking and it is also depends on the RTA temperature and time. Based on these studies it is found that GOI can be easily obtained in the temperatures between 920°C and 925°C. Figure.4 shows X-TEM image of 10 µm crystal grown using single necking technique, seeding window and high resolution picture Ge. Dual necking and height of stressor control the Si diffusion. TEM picture is shown in fig.5.

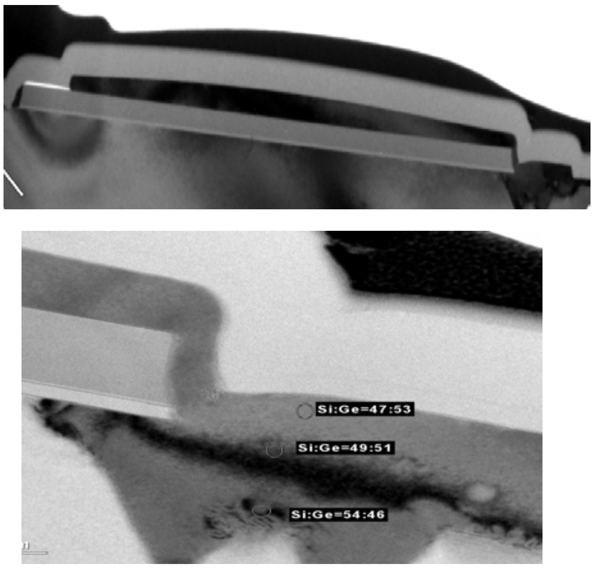

Fig.4(a) TEM image of 10 um pad and (b) seeding window with SiGe gradient.

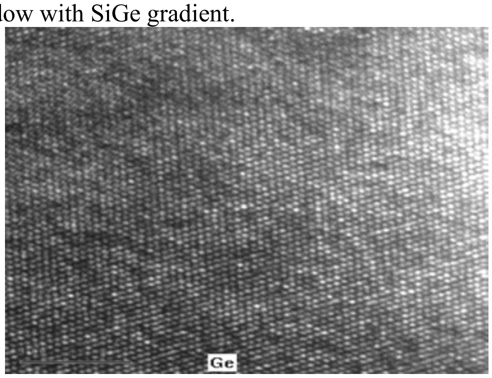

Fig.4 (a) TEM image of 10 um pad, (b) seeding window with SiGe gradient and (c) HRTEM image of Ge crystal.

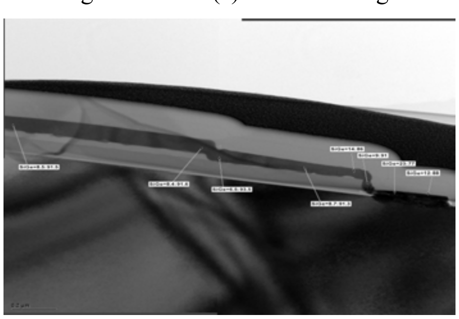

Fig.5 TEM image of GOI crystal using dual necking.

Raman studies were carried out on as grown crystals and films were found to be under tensile stress because of SiN stressor under germanium and the silicon substrate. It was found that tensile stress values changed with RTA temperature which is shown in Fig. 5 (a) and (b). Further results will be discussed in detail.

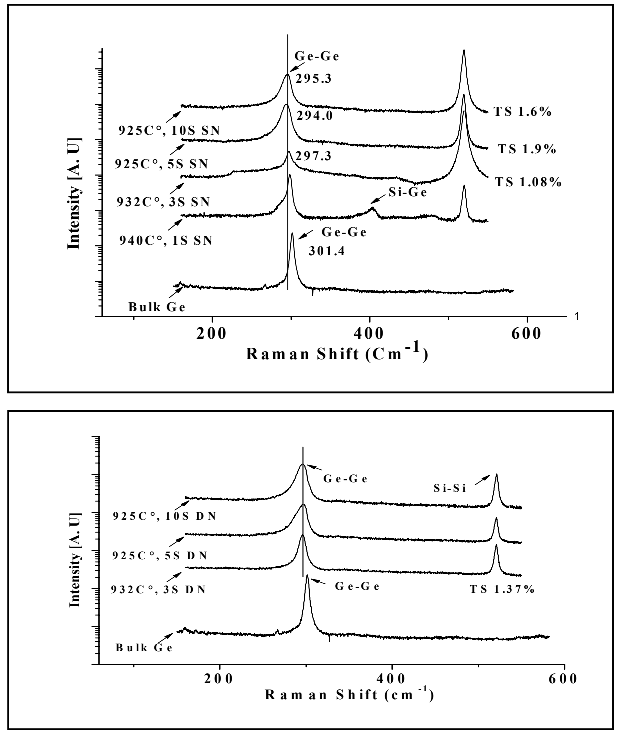

Fig. 6 Raman spectrum of Ge film grown on using and single and dual necking**.**

Summary:

Germanium on Insulator (GOI) single crystal is successfully grown from the temperature below the melting point using RTA. Growth from the semisolid results better crystalline quality and Si diffusion in uniform in the entire crystal in the crystal grown using dual necking technique. Raman studies on the as-grown films show that the films are under tensile strain and its changes with RTA temperatures. Further details will be presented in detail.

References:

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