The SOI Odyssey

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Meeting Abstract

The Odyssey is a Greek epic poem describing the 20 years of wandering by Odysseus after the Trojan Wars and his eventual return to his home on the island of Ithaca and reunion with his faithful wife Penelope. The theme is developed that his adventure is a template for the tortuous paths followed by the competing technologies in the SOI saga that is currently unfolding, almost three millennia later. During her husbands absence, Penelope set up trials of her suitors reminiscent of the tests currently running to establish which SOI technology will grasp the hand of bulk silicon. However, in the Odyssey our hero returns in disguise to ensure that the suitors all die a horrid death - in the case of SOI it is hoped that a front running technology will emerge with the other suitors allowed to live in order to play an important but secondary role.

The concept of fabricating semiconductor devices in a thin film, such as silicon, can certainly be traced as far back as 1926 when the concept appeared in the description of a ‘field effect’ device in the historic patent filed by Lilienfield [1][2]. However, the importance of SOI was not recognized until the late 1950s when the deleterious effects of radiation damage upon semiconductor devices incorporated in the early space satellites was first recorded. It was quickly realized that there was a need to reduce the volume of silicon in which the devices were fabricated and in which photocurrents were generated by the ionising radiation encountered in space. The situation was exacerbated during the early 1960s by the development of integrated circuits incorporating planar MOS transistors, leading to the eventual evolution of CMOS technology, where the active region only required a layer of about 1 micron of silicon and yet was electrically connected to a thick slab of semiconductor of almost a mm thickness, both for manufacturing simplicity and mechanical support. The challenge was to develop a materials technology to produce single crystal silicon thin films that were sufficiently robust to tolerate the rigors of device manufacture.

The major break through came during the early 1960s with the development of the heteroepitaxial growth of single crystal silicon on a single crystal sapphire substrate [3], which was the birth of Silicon on Sapphire (SOS) technology, namely thin film silicon on a thick insulator. Within a few years highly reliable integrated circuits on SOS were incorporated in military and weather satellites giving essentially complete protection from “upsets” triggered by the ionising radiation [4], thus the value of SOI was demonstrated.

In this paper the development of the competing SOI materials technologies during the period since 1970 in laboratories around the world will be reviewed and the current need for these substrates to meet the challenges identified in the International Technology Roadmap for Semiconductors (ITRS2001) will be identified [5]. Using the Odyssey as a template, the trials and tests currently being faced by the competing SOI technologies will be discussed and the evidence to support the suitors claims for the hand of bulk silicon will be critically analysed.

[1] J E Lilienfield, US Patents 1,745,175 (filed 1926, issued 1930) and 1.900.018 (filed 1928, issued 1933).
[2] Silicon on Insulator Technology: Materials to VLSI, 2nd Edition, J-P Colinge, Kluwer Academic Publishers, 2000.
[3] H M Manasevit and W I Simpson, Recent News Paper, American Phys Soc, Edmonton, Canada, 1963.
[4] G W Cullen, M T Duffy and A C Ipri, Silicon on Insulator Technology and Devices, Editor S Cristoloveanu, ECS Proc Vol 94-11, 5-15, 1994.
[5] <www.public.itrs.net>