Crystallinity control in silicon and silicon carbide devices through selective laser annealing

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Nowadays, our everyday life is strongly dependent on the use of portable electronics. The widely diffusion of these devices has been determined by the large improvements in the fabrication of silicon and silicon-based components which constantly increase device performances and decrease fabrication costs. Silicon is an intrinsic semiconductor, whose optical, electrical, and structural properties can be regulated by doping it with other atom species. Especially in the electronic industry, where the doping is often required to be on restricted and well-defined silicon areas, the addition of atoms is accomplished through ion implantation to locally increase the electrical conductivity. This process causes random atoms rearrangement in the target first layers and only a thermal treatment can establish again a reticular order to obtain the proper electrical properties (Fig.1).

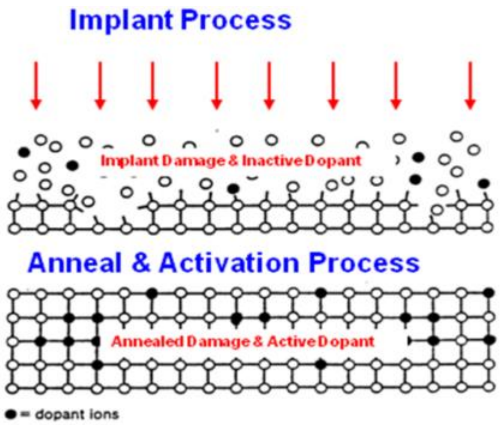

Figure 1. Schematic of the silicon implantation and successive annealing (reprinted from intechopen.com).

Such thermal treatments are often supplied by oven with temperatures up to 1000°C The main disadvantage, is that the whole doped silicon substrate is treated at the same time, often causing an excessive dopant atoms migration. Moreover, this process cannot be applied in new generation power devices where silicon wafer is thinned even below 100 μm but, only after completing the device in the front side. For this reason, the silicon laser annealing has been introduced to provide spatially controlled energy doses for short periods of time and locally control the temperature increase. In the present work, laser annealing was applied to silicon substrates employed in the field of power electronics. A customized setup was used to evaluate the different silicon response by varying laser fluency and scan velocity. Different laser wavelengths were also investigated (532 nm and 1064 nm) on silicon substrates with thickness of 400 μm and 150 μm thin. This analysis confirmed that is possible to achieve a proper re-crystallization of silicon doped region exploiting laser annealing process. A similar setup can also be employed to crystalize in 4H form amorphous silicon carbide thin film deposited by CVD, a novel approach which allow the deposition of crystalline SIC over silicon wafer avoiding wafer bonding or high temperature epitaxially grown.