Executive Summary

Title: Deterministic Doping – A Perspective

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Introduction

With dimensions scaling as part of every generation, doping concentrations need tighter control. Deterministic doping is a method based on the premise that atomistically precise control of dopant position and composition are needed as device dimensions scale. "Deterministic" fabrication refers to 3D nanopatterning and assembly methods that provide sufficient control of the composition and structure of doped interfaces which yield several orders of magnitude improvements in device performance variability. Candidate options are expected to address 1) accurate control of the number and position of dopants, 2) statistical fluctuation of dopant numbers on device characteristics, 3) compatibility and integration with existing fabrication platforms, and 4) economics.

The progress of selected topics over the past five years including your results

From a broader perspective, doping can be viewed as the option to modulate charge density and current in semiconductors. With this definition, the problem of doping can be broken down into control of semiconductor bulk and interface electronic properties. On a silicon substrate, although this is accomplished by doping, for compound semiconductors, doping can be substituted with appropriate chemical incorporation. Compounds which can be tailored have become a reall possibility since the introduction of high-k materials and metal gates in main stream semiconductor technology by Intel at 45 nm. Since a single device performance is still going to be determined by the bulk and the interfaces, synthesis of chemically stable nano-systems would be the key (slower chemical debonding compared to the lifetime of the device). As a result, our premise is that better synthesis and characterization (both experimental and theoretical) methods are the critical items of focus from ITRS perspective. This will address most of the items required for the candidate options mentioned earlier.

Potential application opportunities, if possible (What is the potential impact on ITRS?)

Our premise is that better synthesis and characterization (both experimental and theoretical) methods are the critical items of focus from ITRS perspective. This will address most of the items required for the candidate options mentioned earlier including ability to measure properties, characterize material structures and ability to develop synthesis techniques that can be scaled up.

The difficult challenges and potential solutions for the next 10 – 15 years

Experts and expertise with references