

**Novel Transistors by Damage-free Doping Method and Microwave Annealing for Sub-7nm Node**

**Yao-Jen Lee<sup>1</sup>, Ta-Chun Cho<sup>2</sup>, Po-Jung Sung<sup>1</sup> – <sup>1</sup>National Nano Device Laboratories, <sup>2</sup> Taichung Municipal Siang-Shang Junior High School**

A novel junctionless (JL) FinFET structure with a shell doping profile (SDP) formed by molecular monolayer doping (MLD) method and microwave annealing (MWA) at low temperature is proposed and studied. Thanks to the ultra thin SDP leading to an easily-depleted channel, the proposed JLFinFET can retain the ideal subthreshold swing ( $\sim 60$  mV/dec) at a high doping level according to simulations.

Poly Si based JLFinFETs processed with MLD and MWA exhibit superior subthreshold swing (S.S.  $\sim 67$  mV/dec) and excellent on-off ratio ( $>10^6$ ) for both n and p channel devices. Threshold voltage ( $V_{TH}$ ) variation due to random dopant fluctuation (RDF) is reduced in MLD-JLFinFETs, which can be attributed to the molecule self-limiting property of MLD on the Si surface and quasi-diffusionless MWA at low temperature. Our results reveal the potential of the proposed SDP enabling a JLFinFET showing reduced variation and outstanding performance for low power applications. Figure 1 shows the schematic illustration of MLD-JLFinFETs with monolayer doping in narrow fin structure resulting in shell doping profile. In addition, a combination of microwave annealing (MWA) and CO<sub>2</sub> laser spike annealing (COLSA) is also demonstrated. MWA drives in and partially activates the MLD dopants. The dopant activation of the devices experienced MLD and MWA is further enhanced by the nonmelting COLSA without dopant diffusion, and which can also avoid fin deformation and recover surface defects left by fin patterning.

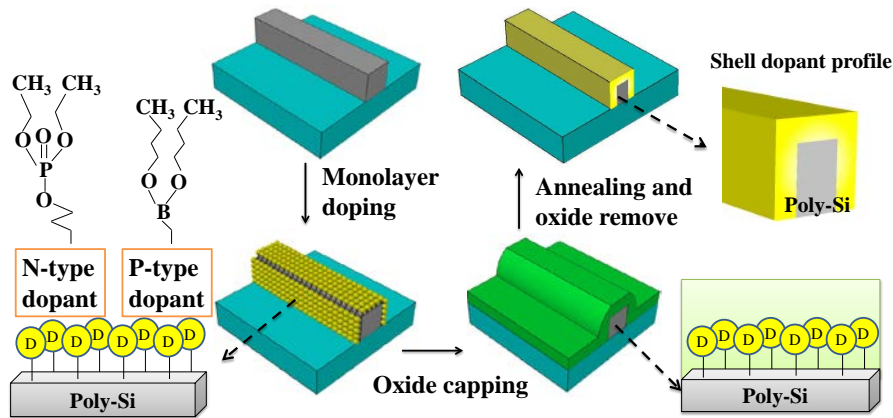


Fig. 1 Schematic illustration of MLD-JLFinFETs with monolayer doping in narrow fin structure resulting in shell doping profile.

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