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Crystal-Orientation-Tolerant Voltage Regulator using Monolithic 3D BEOL FinFETs in Single-Crystal Islands for On-Chip Power Delivery Network

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Abstract

A single-crystal-island (SCI) technique is demonstrated using low thermal budget pulse laser process to fabricate single-crystal islands for monolithic 3D back-end-of-line (BEOL) FinFET circuits. The grain-boundary free Si FinFETs thus fabricated exhibit steep sub-threshold swing (<70mV/dec.), high driving currents (n-type: 363 μA/μm and p-type: 385 μA/μm), and high I_{on}/I_{off} (>10^6). According to simulation, the thickness of the interlayer dielectric plays an important role and shall be thicker than 250nm so that the sequential pulse laser crystallization process does not heat the bottom devices and interconnects to more than 400 °C. The single-crystallinity are verified with SECCO etch, HREM, TEM, and EBSD. BEOL FinFETs fabricated in the designed single-crystal Si islands exhibit excellent electrical performance and low intra-island variability. To mitigate the effects of island-to-island device variation due to random island crystal orientations, crystal -orientation-tolerant voltage regulator is further proposed by allocating power gating (PG) cells among multiple Si islands, and 42% power noise suppression can be achieved.