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| | **INDIAN INSTITUTE OF TECHNOLOGY BOMBAY**<br><br>**MATERIALS MANAGEMENT DIVISION**<br><br>**Powai, Mumbai 400076.** |

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## Epitaxial Growth of Si/SiGe heterostructures on Si(100) substrates with subsurface strained Si quantum well

| Sr. No. | Feature | Specification | Technical compliance (YES/NO) | Additional information (if any) |
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| 1 | Substrate | Single-side-polished p-type Silicon wafers of 200 mm diameter, with miscut angle ≤ 0.5°, thickness varying between 500 μm to 750 μm and resistivity varying between 10 Ohm-cm and 100 Ohm-cm. | | |
| 2 | Heterostructure | **SAMPLE 1 (2 Nos.)**<br><br>**Layer 1**: 3-μm-thick, linearly graded $Si_{1-x}Ge_x$ buffer layer with Ge content (x) varying from x = 0 in the bottom, to x = 0.3 in the end.<br><br>**Layer 2**: 1-μm-thick, $Si_{1-x}Ge_x$ buffer layer with constant Ge content (x) x = 0.3.<br><br>**Layer 3:** 225-nm thick, $Si_{1-x}Ge_x$ buffer layer with constant Ge content (x) x = 0.3.<br><br>**Layer 4:** 8-nm thick, Si quantum well.<br><br>**Layer 5:** 40-nm thick, $Si_{1-x}Ge_x$ buffer layer with constant Ge content (x) x = 0.3.<br><br>**Layer 6:** 2-nm thick, Si cap. | | |

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| | | **SAMPLE 2 (4 Nos.)**<br><br>**Layer 1**: 3-μm-thick, linearly graded $Si_{1-x}Ge_x$ buffer layer with Ge content (x) varying from x = 0 in the bottom, to x = 0.3 in the end.<br><br>**Layer 2**: 1-μm-thick, $Si_{1-x}Ge_x$ buffer layer with constant Ge content (x) x = 0.3.<br><br>**Layer 3:** 225-nm thick, $Si_{1-x}Ge_x$ buffer layer with constant Ge content (x) x = 0.3.<br><br>**Layer 4:** 8-nm thick, Si quantum well.<br><br>**Layer 5:** 50-nm thick, $Si_{1-x}Ge_x$ buffer layer with constant Ge content (x) x = 0.3.<br><br>**Layer 6:** 2-nm thick, Si cap.<br><br>**SAMPLE 3 (2 Nos.)**<br><br>**Layer 1**: 3-μm-thick, linearly graded $Si_{1-x}Ge_x$ buffer layer with Ge content (x) varying from x = 0 in the bottom, to x = 0.3 in the end.<br><br>**Layer 2**: 1-μm-thick, $Si_{1-x}Ge_x$ buffer layer with constant Ge content (x) x = 0.3.<br><br>**Layer 3:** 225-nm thick, $Si_{1-x}Ge_x$ buffer layer with constant Ge content (x) x = 0.3. The $Si_{1-x}Ge_x$ buffer layer should contain isotopically purified Si, with the $^{29}Si$ isotope reduced to 800 ppm or lower.<br><br>**Layer 4:** 8-nm thick, Si quantum well. The quantum well should contain isotopically purified Si, with the $^{29}Si$ isotope reduced to 800 ppm or lower.<br><br>**Layer 5:** 40-nm thick $Si_{1-x}Ge_x$ buffer layer with constant Ge content (x) x = 0.3. The $Si_{1-x}Ge_x$ buffer layer should contain isotopically purified Si, with the $^{29}Si$ | | |

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| | | isotope reduced to 800 ppm or lower.<br><br>**Layer 6:** 2-nm thick, Si cap.<br><br>**SAMPLE 4 (3 Nos.)**<br><br>**Layer 1**: 3-μm-thick, linearly graded $Si_{1-x}Ge_x$ buffer layer with Ge content (x) varying from x = 0 in the bottom, to x = 0.3 in the end.<br><br>**Layer 2**: 1-μm-thick, $Si_{1-x}Ge_x$ buffer layer with constant Ge content (x) x = 0.3.<br><br>**Layer 3:** 225-nm thick, $Si_{1-x}Ge_x$ buffer layer with constant Ge content (x) x = 0.3. The $Si_{1-x}Ge_x$ buffer layer should contain isotopically purified Si, with the $^{29}Si$ isotope reduced to 800 ppm or lower.<br><br>**Layer 4:** 8-nm thick, Si quantum well. The quantum well should contain isotopically purified Si, with the $^{29}Si$ isotope reduced to 800 ppm or lower.<br><br>**Layer 5:** 50-nm thick $Si_{1-x}Ge_x$ buffer layer with constant Ge content (x) x = 0.3. The $Si_{1-x}Ge_x$ buffer layer should contain isotopically purified Si, with the $^{29}Si$ isotope reduced to 800 ppm or lower.<br><br>**Layer 6:** 2-nm thick, Si cap.<br><br>**SAMPLE 5 (3 Nos.)**<br><br>**Layer 1**: 3-μm-thick, linearly graded $Si_{1-x}Ge_x$ buffer layer with Ge content (x) varying from x = 0 in the bottom, to x = 0.3 in the end.<br><br>**Layer 2**: 1-μm-thick, $Si_{1-x}Ge_x$ buffer layer with constant Ge content (x) x = 0.3.<br><br>**Layer 3:** 225-nm thick, $Si_{1-x}Ge_x$ buffer layer with constant Ge content (x) x = 0.3. | | |

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| | | The $Si_{1-x}Ge_x$ buffer layer should contain isotopically purified Si, with the $^{29}Si$ isotope reduced to 800 ppm or lower.<br><br>**Layer 4:** 8-nm thick, Si quantum well. The quantum well should contain isotopically purified Si, with the $^{29}Si$ isotope reduced to 800 ppm or lower.<br><br>**Layer 5:** 60-nm thick $Si_{1-x}Ge_x$ buffer layer with constant Ge content (x) x = 0.3. The $Si_{1-x}Ge_x$ buffer layer should contain isotopically purified Si, with the $^{29}Si$ isotope reduced to 800 ppm or lower.<br><br>**Layer 6:** 2-nm thick, Si cap. | | |
| 3 | Process | 1. The required Si wafers, as specified earlier, should be procured and provided by the vendor<br><br>2. All layers should be grown by chemical vapor deposition, using appropriate gas source precursors<br><br>3. A sufficiently low and uniform growth temperature of layers 3, 4, 5 and 6 should be chosen to avoid Ge intermixing of the Si quantum well.<br><br>4. Before growth of layer 3, chemical-mechanical polishing of layer 2 should be carried out. The as-grown thickness of layer 2 should be such that after CMP of this layer, the remaining thickness is 1 μm | | |
| 4 | Metrology | 1. The thickness variation of layers 1, 2 and 3 should be maintained to within 10 % of the specified values, as measured by XTEM<br><br>2. The thickness variation of layers 4, 5 and 6 should be maintained | | |

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| | | to within ± 1 nm of the specified values, as measured by XTEM<br><br>3. The Ge-content of the $Si_{1-x}Ge_x$ layers (layers 1, 2, 3 and 5) should be maintained to within 1 % of the specified values, as measured by SIMS<br><br>4. All thickness and composition calibration data should be provided along with the heterostructure samples.<br><br>5. The specifications of the used wafers, supporting compliance to the specifications provided for the same, should be provided by the vendor. | | |