N type SiGe parabolic quantum wells for the ultrastrong light matter coupling at Terahertz frequency

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The strong coupling regime of the light-matter interaction has been recently reported in different physical systems and electromagnetic frequency range, paving the way for the development of novel quantum devices relying on the mixture light-matter nature of polaritons. Strong-coupling regime appears when the electronic transitions (matter) are embedded in a resonant optical cavity. Intersubband (ISB) transitions in parabolic quantum wells (PQWs) have been identified as an optimal system to achieve the strong coupling regime in the THz range because the energy separation of the subbands is constant and the ISB features are theoretically independent from electron density and temperature, making accessible the strong coupling regime also at room temperature [1]. In this work, we revealed ISB polaritons in the Si-foundry-compatible SiGe material system by employing $Si_{1-x}Ge_x$ PQWs. The $Si_{1-x}Ge_x$ PQWs were grown by using UHV chemical vapor deposition on Si(001) [2]. The PQWs were embedded in microcavities with the shape of a square patch antenna fabricated by electron beam lithography. The parabolicity of the $Si_{1-x}Ge_x$ profile has been evaluated by using X ray diffraction and Transmission Electron Microscopy. The ultrastrong light matter interaction is revealed in microcavities embedding SiGe PQWs with absorption resonance at 3.2 THz. The anticrossing behavior of the polariton bands is observed up to 300 K. A Rabi frequency of 0.7 THz is measured highlighting the ultrastrong-coupling regime with $\Omega_R/\omega_0 = 0.2$.

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