INFRARED PHOTO-DETECTORS BASED ON A Ge-DOT/SiGe-WELL FIELD EFFECT TRANSISTOR STRUCTURE

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It is known that Ge-rich quantum dots (QD), which improve absorption at 1.3-1.55 µm due to the smaller bandgap, can be formed through strain relaxation and embedded in the Si matrix without generation of misfit dislocations during epitaxial growth. Due to a limited absorption volume, these structures are usually revealed a low photo-response. In this communication we report a study on a detector structure based on lateral transport through a Ge-dot/SiGe-quantum well (QW) superlattice incorporated in Si. For this structure, photo-carriers are generated through interband transitions mainly in connection with the Ge dots by near infrared excitation. Since these dots are discretely distributed, the carrier transport in the dot layer is very low. The situation is greatly improved when a 2D SiGe well layer is allocated next to the dot layer. In this case, the excited holes can be transferred to the 2D QW layer, which serves as an express channel with high carrier mobility. The device is designed as a MESFET. The parameters of importance to obtain a large source-drain current in the photo-MESFET is the number of carriers in the channel, a proper gate bias that controls the carrier transfer from the discrete Ge dots to the SiGe QW channel, and the device geometrical design (W/L ratio).

A set of samples was grown at temperatures ranging from 500 to 700°C, all of them with 10 QW/QD layers separated by 10 nm Si. Multi-finger mesas were fabricated according to the design with various W/L ratios. Al and Pt were deposited and processed forming contacts for the source/drain and gate, respectively. The devices were made for detection of either normal or edge incident light, with a total device length up to 1.5 mm.

Although a somewhat larger leakage current was measured between the source and drain contacts from these non-optimised devices with no isolation to the substrate, a high photo-response was observed. For the normal incidence of a 200 µm diameter laser beam at 1.31 µm, photo-responsivity values of >100 mA/W were obtained for all samples. The highest observed photo-response so far, from the structure grown at 600 °C, was 140 mA/W (wall-plug value with no correction of any coupling factor) at V_{DS} = 20 V. At 1.55 µm, the measured photo-responsivity was more than 35 mA/W for the same detector. We attribute the reduced photo-response of the structures grown at 500 and 700 °C to the increase of the transition energy, due to enhanced carrier confinement shifts for the smaller dots (500 °C) and Si/Ge inter-mixing at high growth temperature (700 °C). The photo-conductivity was also measured as a function of incident optical power. In this case the I_{DS} increased somewhat sublinearly in a relation of $P_{op}^{0.85}$ to the laser power (see Fig. 1), indicating that the photo-carriers are rather efficiently transferred and measured as the source/drain current. Further opto-electric characterizations on fully processed MESFET detectors are presently underway.

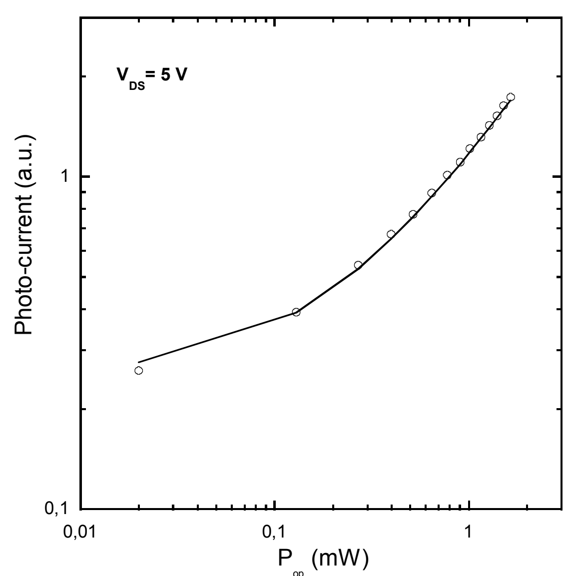

Fig. 1. Power dependence of the photo-current for a device grown at 600°C. The line is the simulated curve ($I_{DS} \propto P_{op}^{0.85}$).