An Al$_{x}$Ga$_{1-x}$As/GaAs quantum-well infrared photodetector (QWIP) of the blocked-intersubband-detector (BID) type, now undergoing development, features a chirped (that is, aperiodic) superlattice. The purpose of the chirped superlattice is to increase the quantum efficiency of the device.

A somewhat lengthy background discussion is necessary to give meaning to a brief description of the present developmental QWIP. A BID QWIP was described in “MQW Based Block Intersubband Detector for Low-Background Operation” (NPO-21073), NASA Tech Briefs Vol. 25, No. 7 (July 2001), page 46. To recapitulate: The BID design was conceived in response to the deleterious effects of operation of a QWIP at low temperature under low background radiation. These effects can be summarized as a buildup of space charge and an associated high impedance and diminution of responsivity with increasing modulation frequency. The BID design, which reduces these deleterious effects, calls for a heavily doped multiple-quantum-well (MQW) emitter section with barriers that are thinner than in prior MQW devices. The thinning of the barriers results in a large overlap of sublevel wave functions, thereby creating a miniband. Because of sequential resonant quantum-mechanical tunneling of electrons from the negative ohmic contact to and between wells, any space charge is quickly neutralized. At the same time, what would otherwise be a large component of dark current attributable to tunneling current through the whole device is suppressed by placing a relatively thick, undoped, impurity-free Al$_{x}$Ga$_{1-x}$As blocking barrier layer between the MQW emitter section and the positive ohmic contact. [This layer is similar to the thick, undoped Al$_{x}$Ga$_{1-x}$As layers used in photodetectors of the blocked-impurity-band (BIB) type.]

Notwithstanding the aforementioned advantage afforded by the BID design, the responsivity of a BID QWIP is very low because of low collection efficiency, which, in turn, is a result of low electrostatic-potential drop across the superlattice emitter. Because the emitter must be electrically conductive to prevent the buildup of space charge in depleted quantum wells, most of the externally applied bias voltage drop occurs across the blocking-barrier layer. This completes the background discussion.

In the developmental QWIP, the periodic superlattice of the prior BID design is to be replaced with the chirped superlattice, which is expected to provide a built-in electric field. As a result, the efficiency of collection of photoexcited charge carriers (and, hence, the net quantum efficiency and thus responsivity) should increase significantly.

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