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The carrier dynamics in low-temperature-grown III-V semiconductors has been investigated using the techniques of femtosecond time-resolved pump-probe and photoluminescence spectroscopies. The samples were grown by molecular beam epitaxy at low temperature. The materials investigated included GaAs, InP, InGaAs, and InGaP. The lasers used in the experimental studies included a 76 MHz optical parametric oscillator pumped by a femtosecond Ti:S laser; a 1 kHz optical parametric amplifier pumped by the output of an amplified femtosecond Ti:S laser; and a femtosecond color center laser system that included a color center amplifier and a white light continuum generator. The laser pulses were tunable across a wide spectral range from the near UV to well in the infrared (past 5 microns).

We discovered that the ultrafast electronic and optical response of these low-temperature-grown semiconductors is much more complex than previously thought. We identified the critical roles of the bandtail states and of the mid-gap defect levels in explaining the subpicosecond recovery time commonly observed by others in single-wavelength experiments above the bandgap. Saturation of these defect levels was possible and led to a dramatic slowing down of the response time, which may be detrimental for the proper operation of ultrafast switches made of these materials. A comprehensive rate equation model was developed to explain these results. We also established the fundamental similarities in the response of the different low-temperature-grown alloys. These results can be used by engineers who need to develop specifications for ultrafast optical, optoelectronic, and electronic devices made of these materials.

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