Fundamental Limitations to Gain Enhancement in Periodic Media and Waveguides

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A common strategy to compensate for losses in optical nanostructures is to add gain material in the system. By exploiting slow-light effects it is expected that the gain may be enhanced beyond its bulk value. Here we show that this route cannot be followed uncritically: inclusion of gain inevitably modifies the underlying dispersion law, and thereby may degrade the slow-light properties underlying the device operation and the anticipated gain enhancement itself. This degradation is generic; we demonstrate it for three different systems of current interest (coupled-resonator optical waveguides, Bragg stacks, and photonic crystal waveguides). Nevertheless, a small amount of added gain may be beneficial.

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