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Subpicosecond optical switching with a negative index metamaterial

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Metamaterials are novel class of materials engineered at the nanoscale to exhibit exotic linear properties of light like negative index of refraction, superlensing and optical cloaking. Recent attempts have been made to actively modulate or control these exotic linear properties via external stimuli like voltage, heat and electromagnetic pulses. Here, we fabricate a fishnet structure metamaterial device exhibiting two negative index resonances in the near-IR. With ultrafast pulses in the visible, we modulate (and recover) the optical properties of the metamaterial in 600 femtoseconds. We demonstrate the utility of this device as an ultrafast all-optical modulator for telecommunication, with a response time two orders of magnitude faster than previously reported. The device is nanoscale, allowing for easy integration into other photonic devices; and structurally tunable over the near-IR.