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Ultrafast phase control in complex oxide heterostructures

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Complex oxide heterostructures have emerged as multifunctional materials of striking flexibility, in which unconventional electronic phases can be realised by engineering the strain field across interfaces. This same mechanical coupling is also expected to be effective on the ultrafast timescale, and could be exploited for the dynamic control of materials properties. Here, we demonstrate that a large-amplitude mid-infrared field, made resonant with a stretching mode of the substrate, can switch the electronic properties of a thin film across an interface. Exploiting dynamic vibrational propagation between different components of a heterostructure, insulating antiferromagnetic $NdNiO_3$ is driven through a prompt, five-order-of-magnitude increase of the electrical conductivity, with resonant frequency and susceptibility that is controlled by choice of the substrate material. Vibrational phase control, extended here to a wide class of heterostructures and interfaces, may be conducive to new strategies for electronic phase control at THz repetition rates.