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Acoustoelectric Control of Optoelectronic Anisotropy for Reconfigurable Polarimetry

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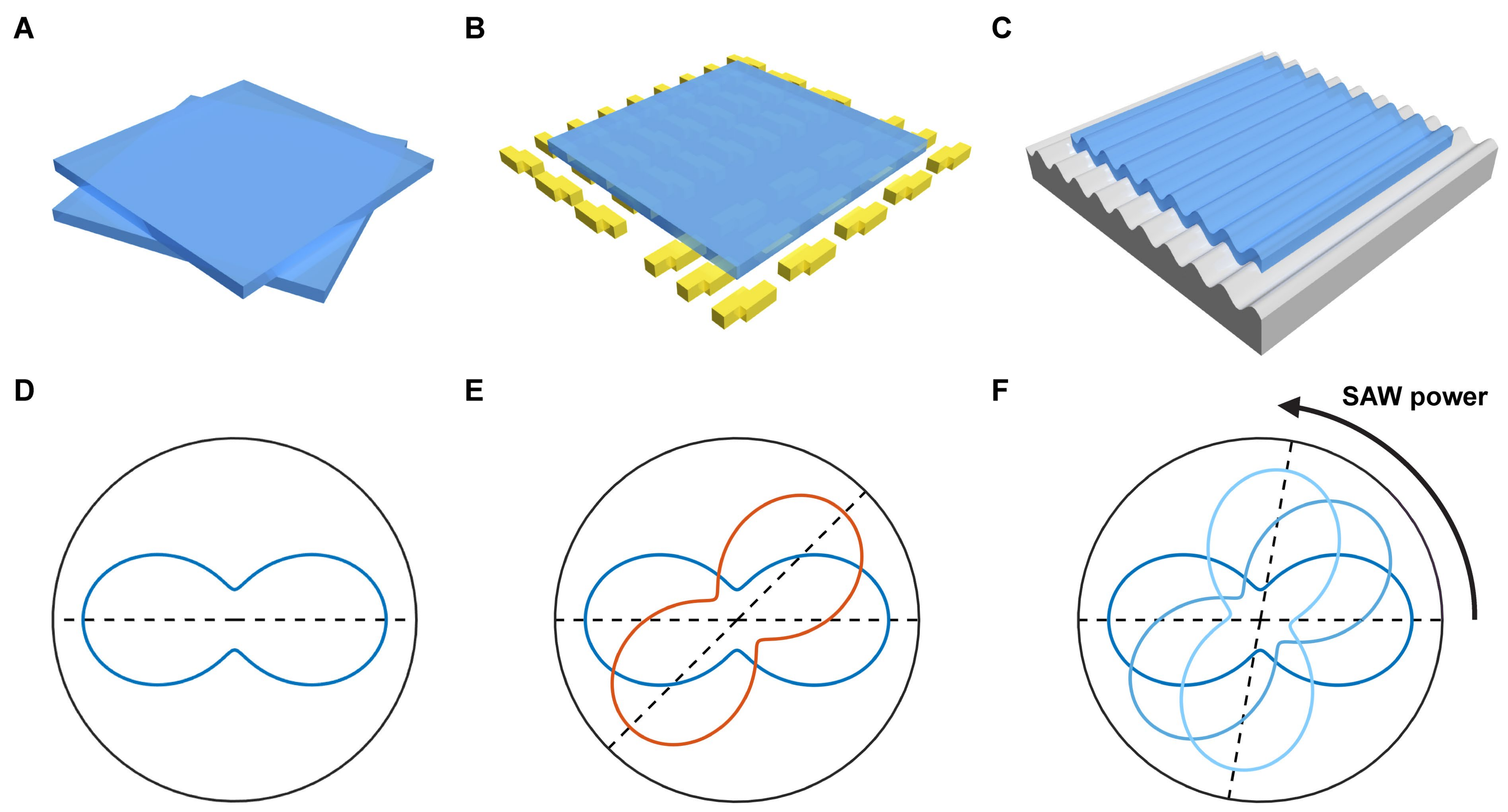
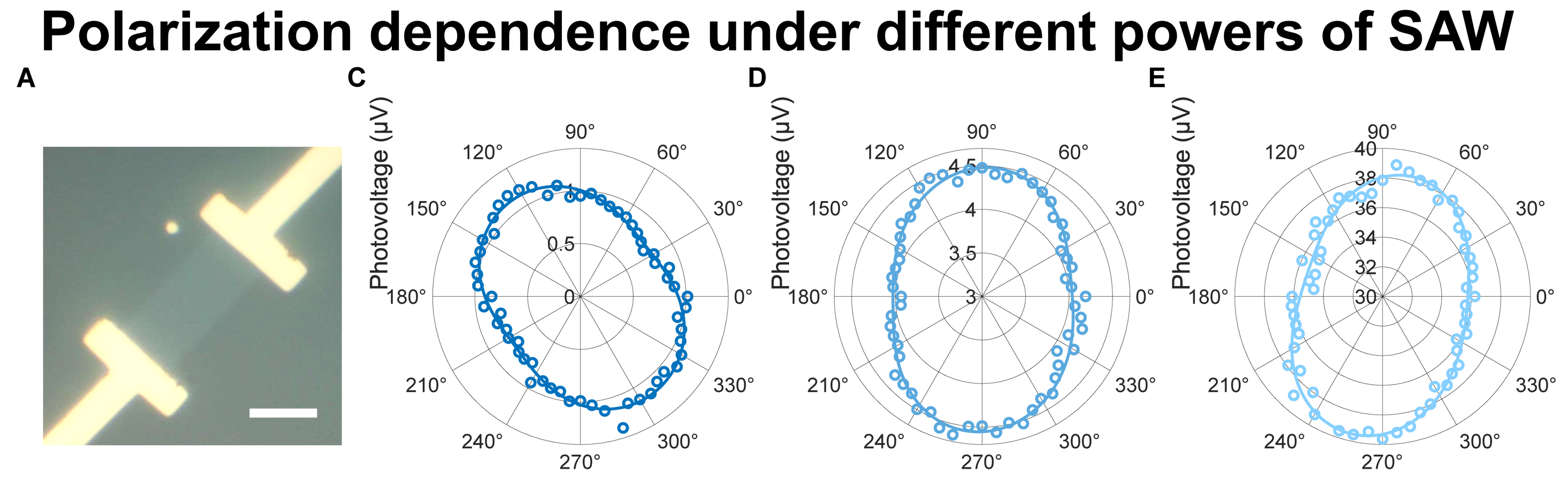
Abstract

Harnessing light polarization provides a powerful degree of freedom for optical communications, imaging, and sensing. Two-dimensional (2D) anisotropic semiconductors have emerged as a promising platform for miniaturized on-chip polarimetry; however, their polarization responses remain constrained by intrinsic crystal symmetries and static device geometries, limiting functional tunability. Here, we demonstrate continuous and dynamic control over optoelectronic anisotropy in a 2D ReS_2 semiconductor through acoustoelectric coupling with surface acoustic waves (SAWs). SAW propagation through the semiconducting channel significantly enhances the photovoltage response via an acousto-drag photovoltaic mechanism. This acoustoelectric coupling not only amplifies the global photoresponse but also continuously rotates its polarization symmetry axis—shifting from the intrinsic orientation of the ReS_2 crystal to that of the $LiNbO_3$ substrate—as the acoustic power increases. Crucially, by adopting a machine learning algorithm, i.e., random forest, we achieve independent and simultaneous detection of both optical power and linear polarization angle within a planar, integrated device. These findings establish a new paradigm in acoustoelectronics for dynamically reconfigurable polarimetry, mediated by hybrid phonon-charge interactions in 2D materials.

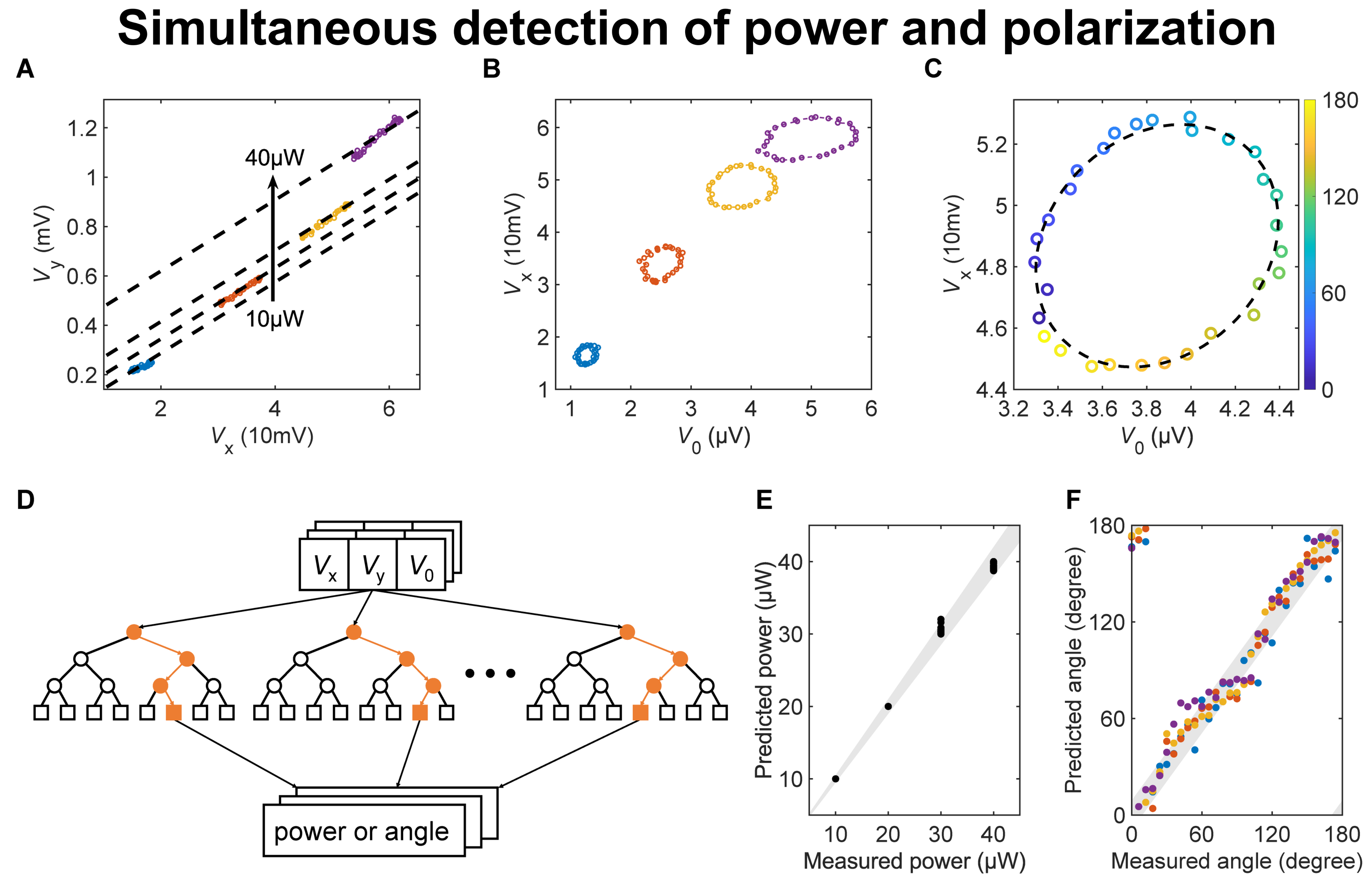
Three configurations to break mirror symmetry



Polarization dependence under different powers of SAW

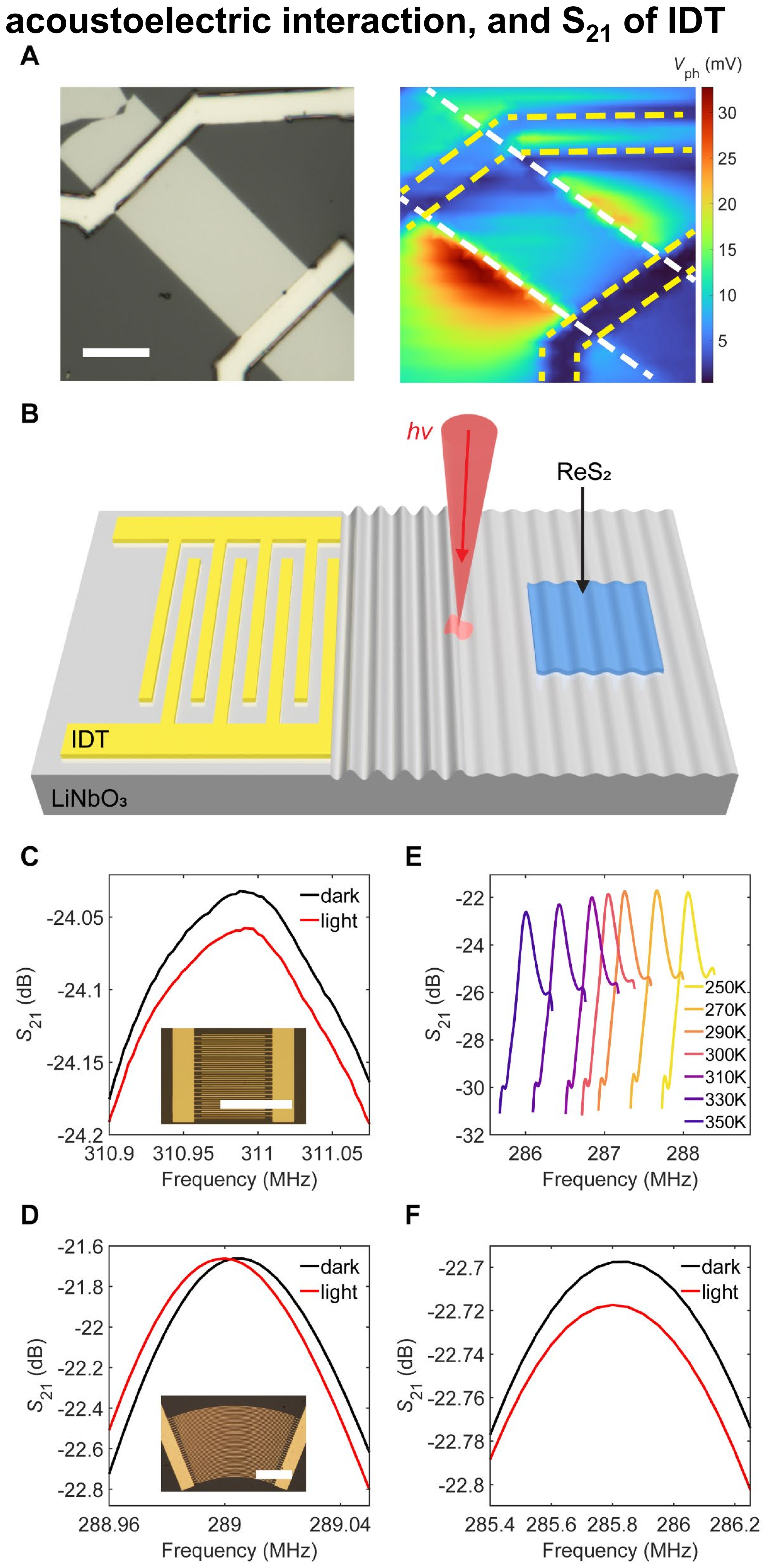


Simultaneous detection of power and polarization



- Tuning polarization dependence continuously
- Collecting data with 40 mW SAW-X, 40mW SAW-Y and without SAW
- Using random forest algorithm to predict power and polarization, falling into the error range of experiment

Mapping of photovoltage, illustration of the acoustoelectric interaction, and S_{21} of IDT



Highlights

- New optoelectronic mechanism
- Confirmed with experiment and simulation
- Dynamic control of polarization dependence
- Simultaneous multidimensional detection

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