

$(a_L^\dagger a_R^\dagger | \text{vac})$ given an expected mean number of events $\mu_0 = d^2 N p_s$ consistent with zero concurrence, where $p_s = 1.0 \times 10^{-3}$ is the probability of generating a Stokes heralding photon and N is the number of experimental runs. Our results ($X = 3$, $N = 1.9 \times 10^{14}$, and $\mu_0 = 9.1 \pm 0.9$) indicate positive concurrence at a $98 \pm 1\%$ confidence level. Therefore, based on this detection of entanglement between Stokes and anti-Stokes modes, we can infer entanglement between the phonon modes of two macroscopic solids at room temperature.

Finally, we examine the quality of entanglement generated between the diamonds by neglecting the vacuum component in Fig. 3, which is only caused by inefficiencies in coupling, detection, and readout of the anti-Stokes mode. To do this, we performed quantum state tomography (25) on the joint polarization state of the Stokes and anti-Stokes modes, postselecting on the detection of both photons. The reconstructed state is shown in Fig. 4, and we have subtracted accidental coincidences calculated from the Stokes and anti-Stokes singles rates. These results provide a more complete estimate of the coherence between the two modes than the interference fringes in Fig. 2. The concurrence of this subspace, 0.85, provides an estimate of the achievable entanglement between the two diamond phonon modes as the readout efficiency, coupling, and detector efficiencies approach unity (i.e., $p_{00} \rightarrow 0$). Further, the fidelity to the nearest Bell state $[[HV] +$

$|VH\rangle]/\sqrt{2}$ is 0.91. However, in the presence of real coupling and detection losses, the existence of entanglement can only be inferred from the density matrix in Fig. 3 (22).

In our experiment, short-lived quantum correlations were revealed by combining an ultrafast interferometric pump-probe scheme with photon-counting techniques. The large optical bandwidth enabled the resolution of extremely fast dynamics in the solids, and also operation at high data rates, providing sufficient statistics to establish entanglement even in the presence of losses. This approach lays the foundation for future studies of quantum phenomena in many-body, strongly interacting systems coupled to strongly decohering environments and points toward a novel platform for ultrafast quantum information processing at room temperature.

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Enhancing Hydrogen Evolution Activity in Water Splitting by Tailoring Li^+ - $\text{Ni}(\text{OH})_2$ -Pt Interfaces

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Improving the sluggish kinetics for the electrochemical reduction of water to molecular hydrogen in alkaline environments is one key to reducing the high overpotentials and associated energy losses in water-alkali and chlor-alkali electrolyzers. We found that a controlled arrangement of nanometer-scale $\text{Ni}(\text{OH})_2$ clusters on platinum electrode surfaces manifests a factor of 8 activity increase in catalyzing the hydrogen evolution reaction relative to state-of-the-art metal and metal-oxide catalysts. In a bifunctional effect, the edges of the $\text{Ni}(\text{OH})_2$ clusters promoted the dissociation of water and the production of hydrogen intermediates that then adsorbed on the nearby Pt surfaces and recombined into molecular hydrogen. The generation of these hydrogen intermediates could be further enhanced via Li^+ -induced destabilization of the HO-H bond, resulting in a factor of 10 total increase in activity.

Electrocatalysis of the hydrogen evolution reaction (HER) is critical to the operation of water-alkali electrolyzers (1–6), in which hydrogen is the main product, and chlor-alkali electrolyzers (5, 6), in which it is a side product.

These two technologies are highly energy-intensive and are known to account for ~25 to 30% (87,600 to 92,000 GWh/year) of the total electrical energy consumption by industrial processes in the United States (3, 7). The HER is also an electrochemical reaction of fundamental scientific importance; the basic laws of electrode kinetics, as well as many modern concepts in electrocatalysis, were developed and verified by examining the reaction mechanisms related to the charge transfer-induced conversion of protons (in acid solutions) and water (in alkaline solutions) to molecular hydrogen.

Although previous studies have helped to rationalize which surface properties govern the variations in reactivity among catalysts (8–12), many key questions concerning the HER remain unanswered. For example, it is not clear why the rate of the HER is ~2 to 3 orders of magnitude lower at $\text{pH} = 13$ than at $\text{pH} = 1$, nor why the reaction is sensitive to the catalyst surface structure in alkaline media but largely insensitive in acids (13–17). A practical implication of the slow kinetics in alkaline solution is the lower energy efficiency for both water-alkali and chlor-alkali electrolyzers. For water-alkali electrolyzers, the high overpotentials for the oxygen evolution reaction (OER) at the anode also contribute significantly overall energy losses (18). This has led to various approaches to identify catalysts for both the OER and HER. However, such design strategies have rarely been based on molecular-level understanding of the reaction pathways. In addition, the influence of noncovalent (van der Waals-type) interactions on the overall kinetics of the HER has been underexplored, particularly in light of recent studies highlighting the impact of noncovalent interactions on the rates of many electrochemical reactions such as the oxygen reduction reaction, together with CO and methanol oxidation reactions (19–22).

Currently, various combinations of metals (Pt, Pd, Ir, Ru, Ag, Ni), metal alloys (Ni-Co, Ni-Mn, Ni-Mo), metal oxides (RuO_2), and Ni sulfides and phosphides are used to catalyze the conver-

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