2D semiconductor plasmonic structures

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2D semiconductor nonlinear plasmonic modulators

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Slow light in a 2D semiconductor plasmonic structure

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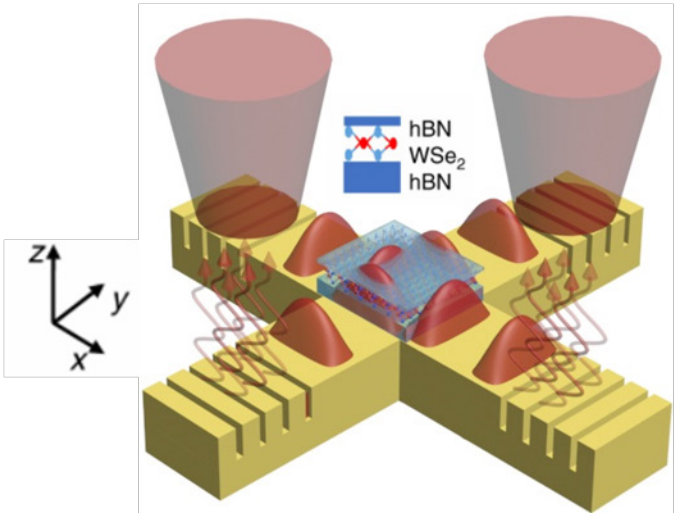
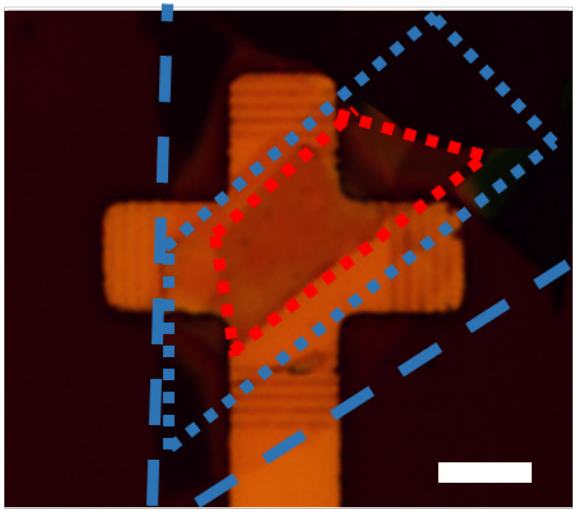
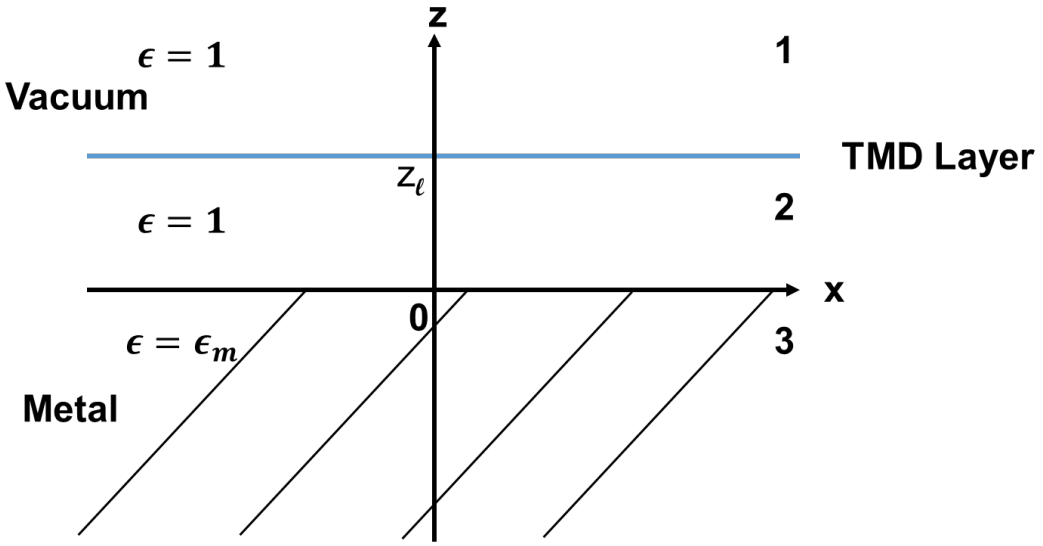
Spectrally narrow optical resonances can be used to generate slow light, i.e., a large reduction in the group velocity. In a previous work, we developed hybrid 2D semiconductor plasmonic structures, which consist of propagating optical frequency surface-plasmon polaritons interacting with excitons in a semiconductor monolayer. Here, we use coupled exciton-surface plasmon polaritons (E-SPPs) in monolayer WSe_2 to demonstrate slow light with a 1300 fold decrease of the SPP group velocity. Specifically, we use a high resolution two-color laser technique where the nonlinear E-SPP response gives rise to ultra-narrow coherent population oscillation (CPO) resonances, resulting in a group velocity on order of 10^5 m/s. Our work paves the way toward on-chip actively switched delay lines and optical buffers that utilize 2D semiconductors as active elements.

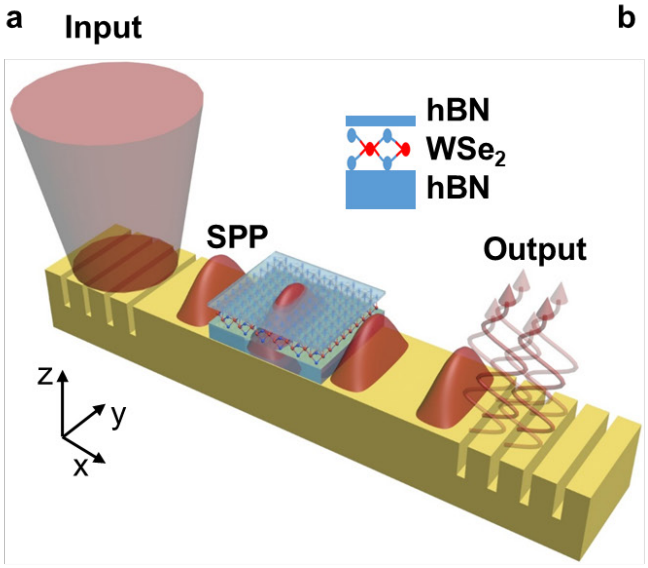
a

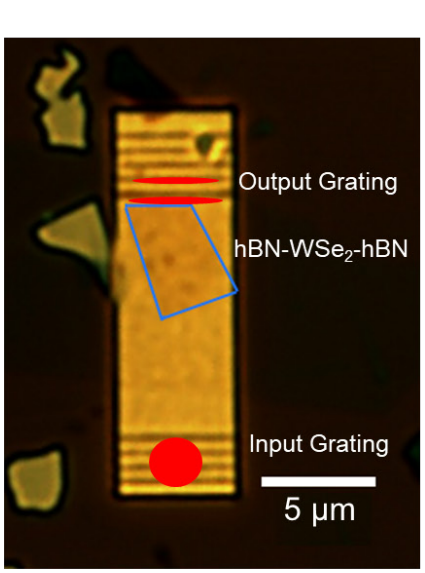

hBN
WSe2
hBN
z
y
x

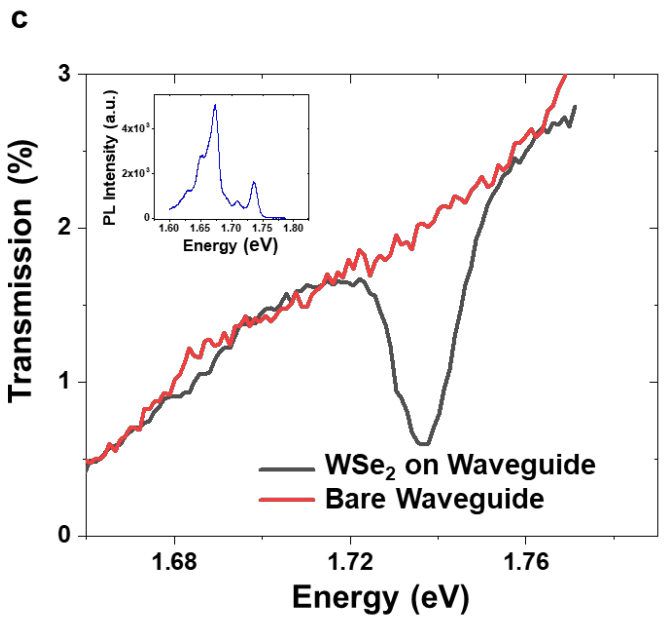
b

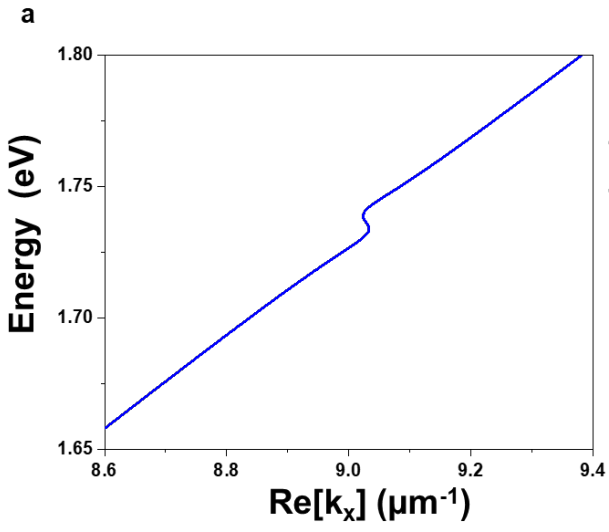


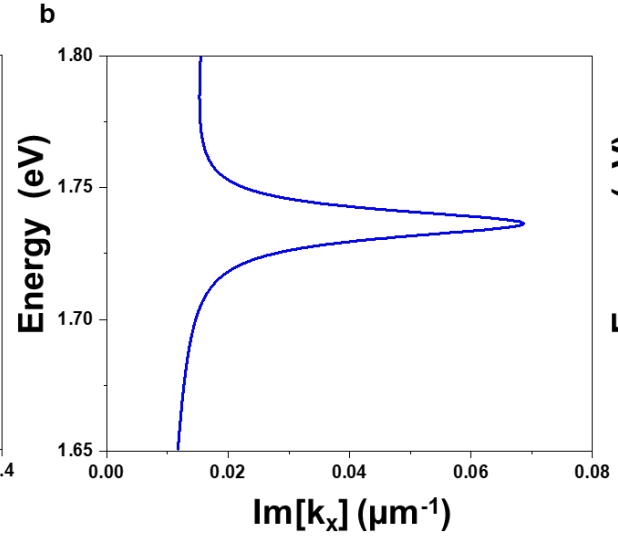

z
$\epsilon = 1$
Vacuum
1
TMD Layer
z_ℓ
$\epsilon = 1$
2
x
0
$\epsilon = \epsilon_m$
3
Metal

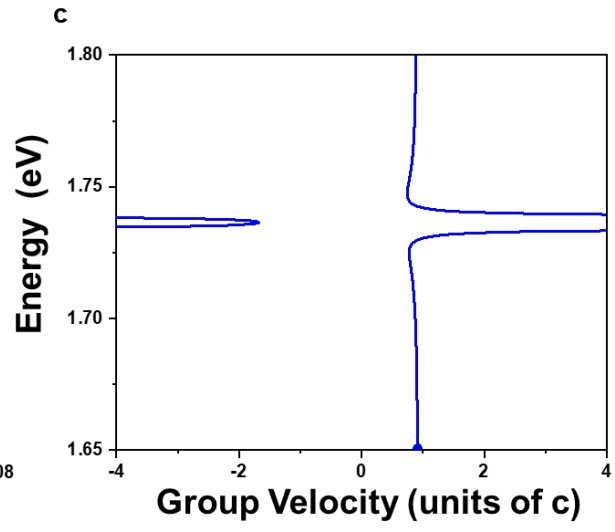

a
Input
hBN
WSe2
hBN
SPP
Output
z
y
x

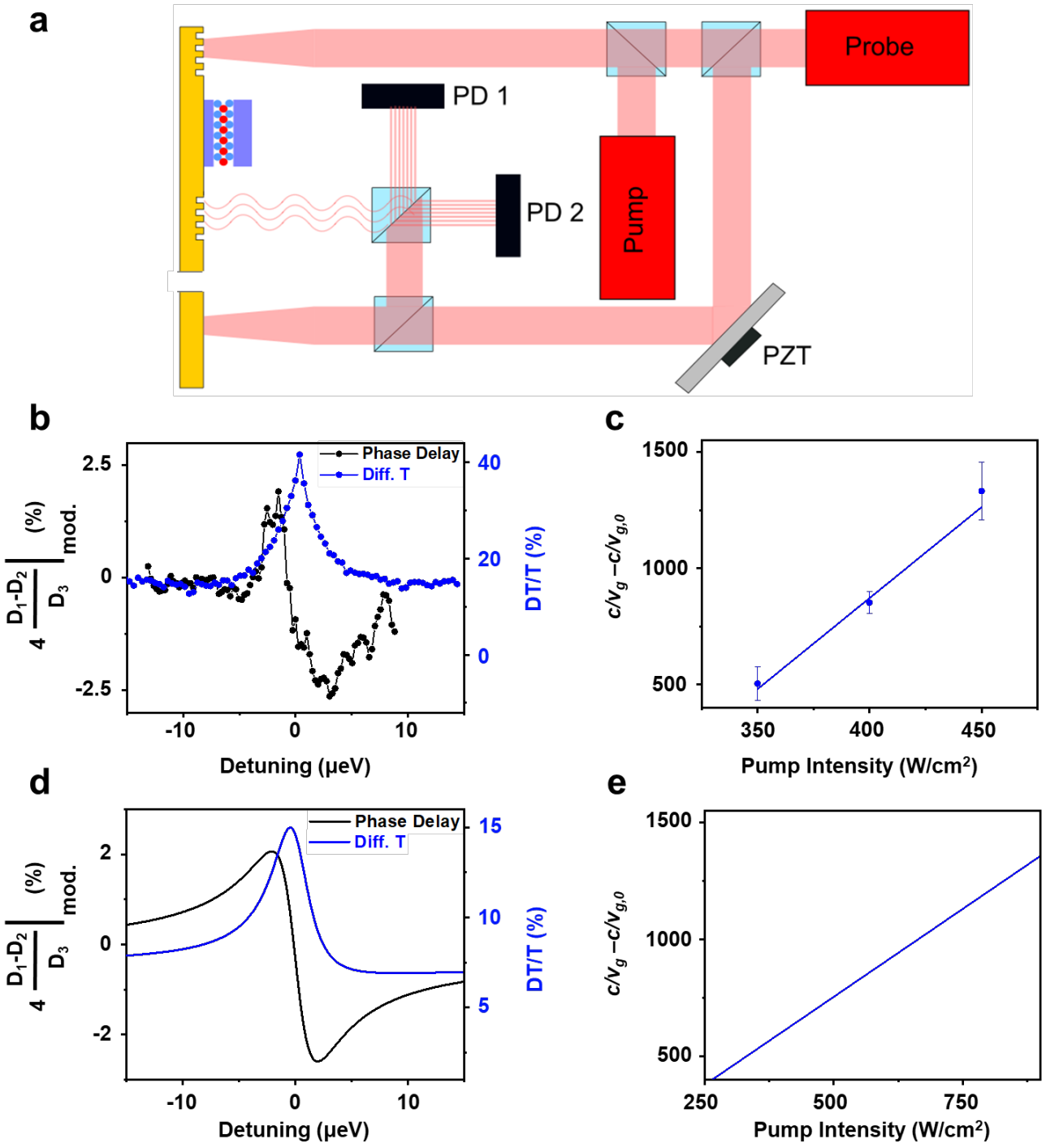

b
Output Grating
hBN-WSe2-hBN
Input Grating
5 μm


c
Transmission (%)
Energy (eV)
PL Intensity (a.u.)
Energy (eV)
WSe2 on Waveguide
Bare Waveguide


a
Energy (eV)
Re[kx] (μm-1)


b
Energy (eV)
Im[kx] (μm-1)


c
Energy (eV)
Group Velocity (units of c)


a
Probe
PD 1
PD 2
Pump
PZT
b
Phase Delay
Diff. T
2.5
0
-2.5
40
20
0
-10
0
10
Detuning (μeV)
DT/T (%)
c
1500
1000
500
350
400
450
Pump Intensity (W/cm²)
d
Phase Delay
Diff. T
2
0
-2
15
10
5
-10
0
10
Detuning (μeV)
DT/T (%)
e
1500
1000
500
250
500
750
Pump Intensity (W/cm²)