基于双面金属波导的慢光实验

Slow light based on ultrahigh-order guided modes in symmetrical metal cladding optical waveguide

在导波光学中，超高阶导模的阶数可高达10^3至10^4，它可以通过自由空间耦合技术被激发且能在亚毫米、毫米厚双面金属波导中长距离传输。超高阶导模的一个重要特点是它在波导中的传播常数很小，即表现出慢光特性。双面金属波导的优点在于它对光有很强的约束能力，可以在很大带宽上约束光在波导中传输，而不受介质波导中内全反射条件的限制。我们在双面金属波导中利用超高阶导模首次实验上在亚皮秒脉冲领域实现了1,400个脉冲延迟量的慢光现象，所得到的延迟带宽积优于10^4。

In optical waveguide, ultrahigh-order guided modes are those whose mode orders are of the order of 10^3 or 10^4. We demonstrate, for the first time, ~1, 400 fractional pulses delay of a sub-ps pulse based on ultrahigh-order guided modes in symmetrical metal-cladding optical waveguide (SMCOW). Extremely large value of delay-bandwidth product (~10^4) is obtained experimentally. Ultrahigh-order guided modes travelling as slow light in waveguide together with strong confinement provided by SMCOW makes this scheme nearly material dispersion independent and compatible with wide bandwidth operation.

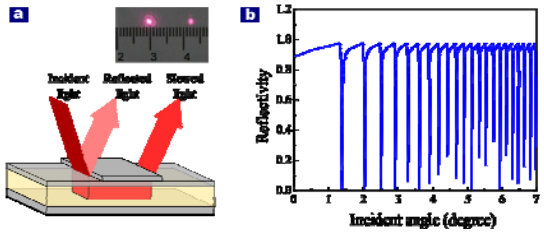

Figure 1 | (a) Symmetrical metal-cladding optical waveguide (SMCOW) And (b) attenuated total reflection spectrum （ATR）
图1 | 双面金属波导及其衰减全反射谱

The input is coupled into SMCOW using free-space coupling technique, Fig. a. Each dip in the ATR spectrum corresponds to the coupling of light into SMCOW, Fig b.

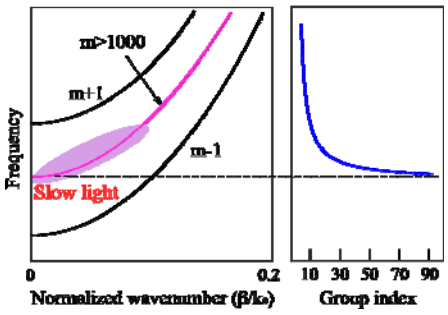

Figure 2 | Dispersion relation and group-index characteristics for SMCOW.
图2 | 双面金属波导的色散关系及群折射率特征

Slow light occurs when normalized wavenumber or effective index approaches zero, that is, the ratio of propagation constant and wavenumber is small.

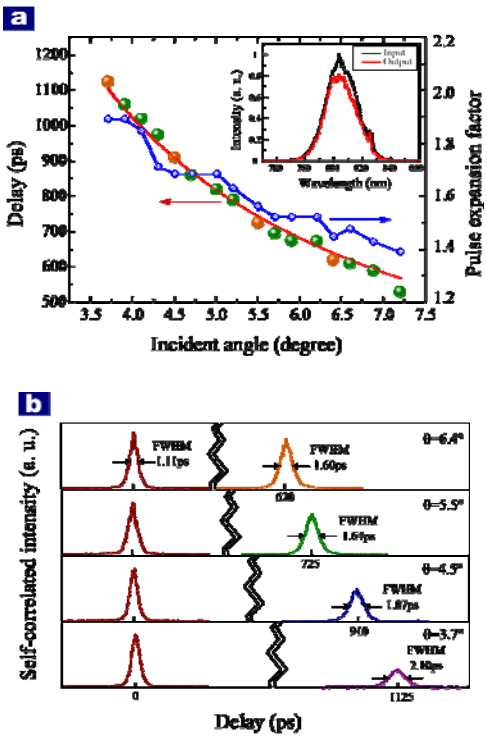

Figure 3 | Measured absolute time delay and pulse expansion
图3 | 实验测量得到的绝对延迟量及展宽

The maximum absolute time delay obtained is 1,125 ps at the incident angle of 3.7 degree, with pulse expansion factor of 1.9. This corresponds to over 1,400 fractional pulse delay, or DBP value of 10^4, which is the highest record to our best knowledge.

先进光子学材料和物理实验室
Laboratory of Advanced Photonic Materials and Physics