空芯光纤赋能低插损宽波段全光相位调制器

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近年来，能够取代“电控光”的全光相位调制器引起研究人员的关注，其采用“光控光”的方式，可以避免光链路中的电光转换，理论上可以不受电子瓶颈限制实现高速调制，且抗电磁干扰，是实现全光信号处理的关键器件。

香港理工大学深圳研究院靳伟教授团队与暨南大学汪滢莹教授团队合作，基于空芯光纤中乙炔气体的光热效应，提出了一种全光纤的低插损、宽波段全光相位调制器。在气体填充的空芯光纤中，气体分子与大部分光能量处于同一空芯区域中，气体分子吸收控制光能量后，由基态跃迁至激发态，随后通过弛豫碰撞过程释放热量，引起气体温度和压强变化，进而改变其折射率，这一过程使得“光控光”的全光相位调制成为可能。

研究团队在空芯反谐振光纤中填充高纯乙炔气体，实验制备了长度约 5.6 cm 的空芯光纤光热相位调制器，在 C+L 波段内平均插入损耗仅 0.6 dB。以波长 1530.371 nm 的激光器作为控制光源，其波长对准乙炔的 P(9) 吸收线，通过调制控制光的功率，可以“光控”信号光的相位。该全光相位调制器的响应时间常数约 3.5 μs，比基于微纳光纤的光热相位调制器好 2-3 个量级，在 100 kHz 调制频率下，实现 π 相位调制所需的半波功率约为 289 mW。

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Broadband low-loss all-optical phase modulator using gas-filled hollow-core fiber

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Although a lot of low-dimensional materials have been studied, there is still a big gap from practical usage. Developing novel all-optical phase modulators with low loss, broad wavelength band, fast response is essential to promote the development of all-optical technology.

The research group of Prof. Wei Jin from the Photonics Research Center at the Shenzhen Research Institute of the Hong Kong Polytechnic University reported a broadband all-fiber optical phase modulator based on the light-gas interaction in a hollow-core fiber (HCF). In the HCF, most of the optical mode power propagates in the hollow core, which is free from absorption of the solid fiber materials. This enables extremely broadband low-loss transmission, from the ultraviolet to the mid-infrared, apart from a few narrow resonant loss bands. The HCF can confine gas phase material, a high intensity control beam and a signal beam simultaneously in the hollow core, providing an ideal platform for strong light-gas interaction over a long interaction length.

An all-optical phase modulator with insertion loss about 0.6 dB within C+L band and half-wave power about 289 mW at 100 kHz is fabricated. It has response time at μs scale, which is 2-3 orders better than the 2D-material-coated microfiber-based all-optical modulators.

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