Abstract

Rapid identification of chemical and biological hazards is essential for improving preparedness and resilience against emerging CBRN threats. Brillouin spectroscopy provides a label-free and non-destructive method to characterize the mechanical properties of liquids, biological samples, and soft materials, offering complementary information to conventional chemical sensing techniques.

We present an integrated silicon photonics Brillouin spectrometer that performs spectral filtering and analysis directly on a silicon nitride chip, eliminating the bulky free-space optics required by conventional instruments. The device achieves sub-GHz spectral resolution, >70 dB Rayleigh suppression, and an overall dynamic range exceeding 90 dB while operating through a standard fiber interface.

The system has been validated on representative liquids, including water, ethanol and acetone, demonstrating accurate discrimination through their characteristic Brillouin signatures. Thanks to its compactness, robustness, and minimal alignment requirements, the technology represents a promising building block for portable CBRN instrumentation, enabling rapid screening and characterization of chemical compounds and biological materials in mobile laboratories and field deployments. This work illustrates how integrated photonics can facilitate the translation of Brillouin spectroscopy from laboratory settings to real-world applications in civil protection, environmental monitoring, and emergency response.