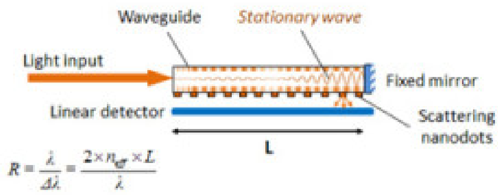
SWIFTS Technology principle

The technology works by probing an optical stationary wave, or the sum of the standing waves in the case of polychromatic light, created by a light to be analyzed. In a SWIFTS linear configuration (true Lippman configuration), the stationary wave is created by a single-mode waveguide ended by a fixed mirror. The stationary wave is regularly sampled on one side of a waveguide using nano-scattering dots. These dots are located in the evanescent field of the standing wave. These nanodots are characterized by an optical index difference with the medium in which the evanescent field is located. The light is then scattered around an axis perpendicular to the waveguide. For each dot, this scattered light is detected by a pixel aligned with this axis. The intensity detected is therefore proportional to the intensity inside the waveguide at the exact location of the dot. This results in a linear image of the interferogram. No moving parts are used.

A mathematical function known as a Lippmann transform, similar to a Fourier transform, is then applied to this linear image and gives the spectrum of the light.

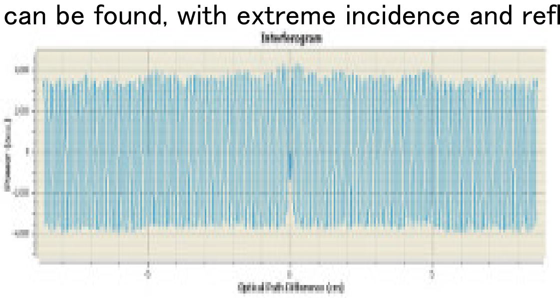


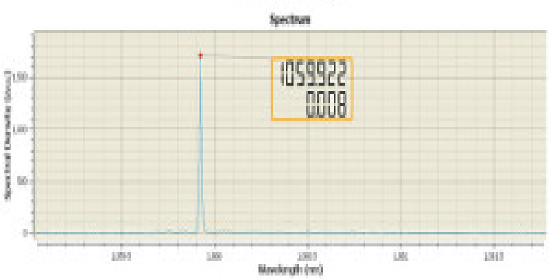
It should be noted that the interferogram is truncated. Only the frequencies corresponding to the zero Optical Path Difference (OPD) at the mirror, up to the farthest dots, are sampled. Higher frequencies are rejected. This interferogram's truncation determines the spectral resolution. It is also to be noted that the interferogram is under-sampled. A consequence of this under-sampling is a limitation of the wavelength bandwidth to which the mathematical function is applied.

The SWIFTS chip can thus be used as an interferometer or a spectrometer. As an interferometer, the chip can measure OPD or optical coherence tomography (OCT) signals directly in the spatial domain or can read time correlation. As a spectrometer, the chip can characterize optical signals when applying a Lippmann transform function on the rough data or select Fourier frequencies, used for example to detect specific Fourier signatures.

SWIFTS can be considered as a condensed and static evolution of the Michelson spectrometer configuration where the moving mirror and the detector are both functionally replaced by the nanodetectors (each formed by a nanodot and a pixel).

The regular pattern of nanodots can evoke a grating spectrometer. And indeed, SWIFTS can also be considered as an optimization of the grating spectrometer configuration: a grating spectrometer is in fact also an interferometric system that creates an OPD between both sides of the grating. We demonstrate that for a given resolving power (even when very high), SWIFTS corresponds to the smallest grating configuration that can be found, with extreme incidence and reflection angles. SWIFTS is not an exotic object but an optimum of





The first of two limitations of the basic configuration illustrated in Figure 1 is that the throughput is that of a single-mode waveguide, which has an optical étendue equal to the square of the wavelength. Second, the nanodetector pitch of a few microns results in a simultaneous band capability of about 5 to 15 nm in the visible/near-IR spectrum, which could be too narrow for some applications.

However, both of these limitations can be overcome by a multiplex configuration consisting of N shifted parallel waveguides coupled to a multimode fiber, which multiplies both the optical étendue and the bandwidth by N (with N typically around 50 to 100). This multiplex configuration is, for instance, able to measure in one integration time a spectral range wider than 4000 cm−1 with no limitation on the spectral resolution and a throughput equivalent to a spectrometer fed by a 200-µm-core multimode fiber through a slit.

The absence of moving parts, the high level of integration, and the linear geometry of the technology guarantee highly robust wavelength calibration that can last for a significant period of time and can withstand frequent temperature fluctuations as well as frequent transportation. Because temperature calibration is taken into account during data processing as a linear thermal-expansion factor, temperature fluctuations during measurement do not reduce the absolute accuracy.