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White Light Interferometry Scanning (WLS):

While white light interferometry is certainly not new, in fact the development of scanning white-light interferometry is in many ways a back-to-basics scenario. As interferometry progressed from using white light to monochromatic light to lasers to computerized fringe analysis to phase shifting techniques, the path has actually led right back to white light. Scanning white-light interferometry combines the power of modern high-speed computers with the vast amount of surface information produced by white-light interferometry. This permits WLS-based systems to measure surface features far more accurately than those measurable with conventional phase-measuring interferometry techniques.

White-light interferometry scanning (WLS) systems capture intensity data at a series of positions along the vertical axis, determining where the surface is located by using the shape of the white-light interferogram. The white light interferogram actually consists of the superposition of fringes generated by multiple wavelengths, obtaining peak fringe contrast as a function of scan position, that is, the red portion of the object beam interferes with the red portion of the reference beam, the blue interferes with the blue, and so forth. In other words, a prodigious amount of data is available in white-light interferograms.

Conventional WLS systems use fringe contrast to yield surface information. Frequency domain analysis (FDA) is an alternate approach that uses all of the information available in the interferogram. This Fourier analysis method is used to convert intensity data to the spatial frequency domain, allowing production of an extremely accurate surface map.

In a WLS system, an imaging interferometer is vertically scanned to vary the optical path difference. During this process, a series of interference patterns are formed at each pixel in the instrument field of view. This results in an interference function, with interference varying as a function of optical path difference. The data are stored digitally and Fourier-transformed into frequency space.

At this point the original intensity data are expressed in terms of interference phase as a function of wavenumber. Wavenumber k is just a representation of wavelength in the spatial frequency domain, defined by $k = 2p/l$. If phase is plotted versus wavenumber, the slope of the function corresponds to the relative change in group-velocity optical path difference DG by $Dh = DG/2nG$ where nG is group-velocity index of refraction. If this calculation is performed for each pixel, a three-dimensional surface height map emerges from the data.

In the actual measuring process, the optical path difference is steadily increased by scanning the objective vertically using a precision piezoelectric positioner. Interference data are captured at each step in the scan. In effect, an interferogram is captured as a function of vertical position for each pixel in the detector array. To sift through the large amount of data acquired over long scans, a patented technique involving both acquisition and processing algorithms is used. This method allows the instrument to reject raw data that do not exhibit the intensity variations that indicate white-light fringes.

Using discrete Fourier-transform techniques, the intensity data as a function of the optical path difference are converted to the spatial frequency domain.