this is easily performed in a single photolithographic and etch step. Extended modeling is done for both the DFB cavity and the coupling with the waveguide via the integrated probe. The DFB structure QCL has an integrated waveguide probe suitable for mounting in a machined waveguide block. Following fabrication of the MM-waveguide, the wafer can be mounted top-down on a temporary support wafer, and the GaAs receptor substrate is thinned to a membrane with the assistance of an etch-stop layer.

Development of a demonstrator horn-antenna coupled QCL at 2.7 THz with Gaussian output beam profile and high coupling efficiency capable of effectively pumping mixers at these frequencies is a major breakthrough in the spectroscopic studies for the Earth-observation and astrophysics community. The approach, which includes an integrated probe on the QCL device in a waveguide enclosure transitioning to a diagonal horn, may lead to compact, coherent, continuous-wave solid-state sources.

A phase-locked terahertz QCL source with high-quality beam profile and excellent output coupling efficiency operating at or above liquid nitrogen temperatures will be of great strategic importance for NASA's astrophysics, Earth, and planetary mission capabilities. This will make these QCLs the local oscillator source of choice for the future NASA and European suborbital and orbital terahertz instruments for astrophysics missions such as the interferometric (ESPRIT) and other single- and multi-pixel heterodyne spectroscopic missions, as well as for Earth observing and planetary missions. A high-power QCL with good beam profile can also be used in biological and medical science instruments, security screening and illicit material detection, and nondestructive evaluation applications.

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Measurement Via Optical Near-Nulling and Subaperture Stitching

This simple and universal technique uses adjustable corrective optics.

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A subaperture stitching interferometer system provides near-nulling of a subaperture wavefront reflected from an object of interest over a portion of a surface of the object. A variable optical element located in the radiation path adjustably provides near-nulling to facilitate stitching of subaperture interferograms, creating an interferogram representative of the entire surface of interest. This enables testing of aspheric surfaces without null optics customized for each surface prescription.

The surface shapes of objects such as lenses and other precision components are often measured with interferometry. However, interferometers have a limited capture range, and thus the test wavefront cannot be too different from the reference or the interference cannot be analyzed. Furthermore, the performance of the interferometer is usually best when the test and reference wavefronts are nearly identical (referred to as a "null" condition). Thus, it is necessary when performing such measurements to correct for known variations in shape to ensure that unintended variations are within the capture range of the interferometer and accurately measured.

This invention is a system for near-nulling within a subaperture stitching interferometer, although in principle, the concept can be employed by wavefront-measuring gauges other than interferometers. The system employs a light source for providing coherent radiation of a subaperture extent. An object of interest is placed to modify the radiation (e.g., to reflect or pass the radiation), and a variable optical element is located to interact with, and nearly null, the affected radiation. A detector or imaging device is situated to obtain interference patterns in the modified radiation. Multiple subaperture interferograms are taken and are "stitched," or joined, to provide an interferogram representative of the entire surface of the object of interest.

The primary aspect of the invention is the use of adjustable corrective optics in the context of subaperture stitching near-nulling interferometry, wherein a complex surface is analyzed via multiple, separate, overlapping interferograms. For complex surfaces, the problem of managing the identification and placement of corrective optics becomes even more pronounced, to the extent that in most cases the null corrector optics are specific to the particular asphere prescription and no others (i.e. another asphere requires completely different null correction optics). In principle, the near-nulling technique does not require subaperture stitching at all.

Building a near-null system that is practically useful relies on two key features: simplicity and universality. If the system is too complex, it will be difficult to calibrate and model its manufacturing errors, rendering it useless as a precision metrology tool and/or prohibitively expensive. If the system is not applicable to a wide range of test parts, then it does not provide significant value over conventional null-correction technology. Subaperture stitching enables simpler and more universal near-null systems to be effective, because a fraction of a surface is necessarily less complex than the whole surface (excepting the extreme case of a fractal surface description). The technique of near-nulling can significantly enhance aspheric subaperture stitching capability by allowing the interferometer to capture a wider range of aspheres. Moreover, subaperture stitching is essential to a truly effective near-nulling system, since looking at a fraction of the surface keeps the wavefront complexity within the capability of a relatively simple near-null apparatus. Furthermore, by reducing the subaperture size, the complexity of the measured wavefront can be reduced until it is within the capability of the near-null design.

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