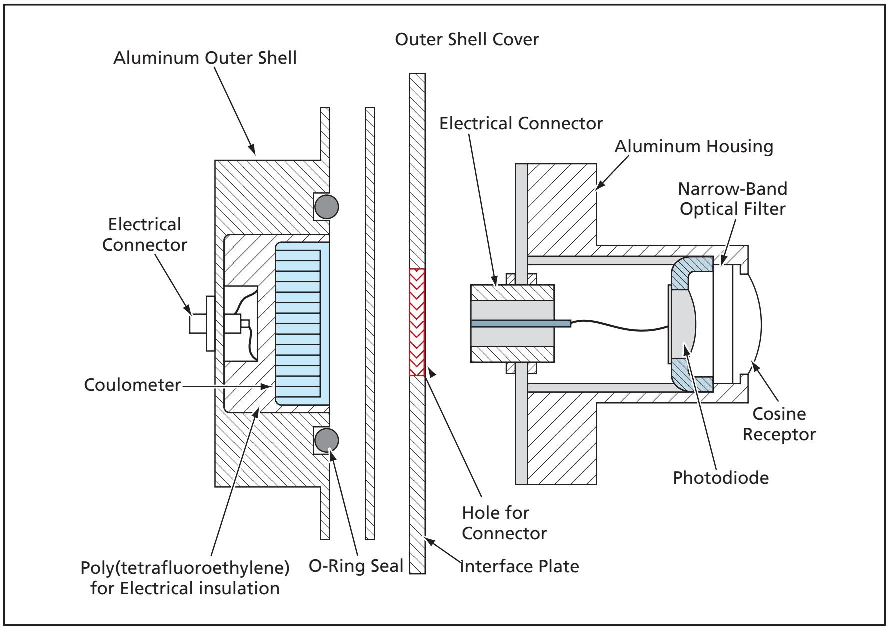
mates the ideal angular response (proportional to the cosine of the angle of incidence). The filter is chosen to pass the ultraviolet wavelength of interest in a specific experiment.

The photodiode is electrically connected to the coulometer. The factor of proportionality between the charge stored in the coulometer and ultraviolet dosage (in units of ESH) is established, prior to use, in calibration experiments that involve the use of lamps and current sources traceable to the National Institute of Standards and Technology.

This work was done by Jason A. Vaughn of **Marshall Space Flight Center** *and Perry Gray of Micro Craft, Inc.*

This invention is owned by NASA, and a patent application has been filed. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at (256) 544-5226 or sammy.a.nabors@nasa.gov. Refer to MFS-31316-1.



This **Simple, Passive Instrument** measures the dosage of ultraviolet light in the pass wavelength band of its filter.

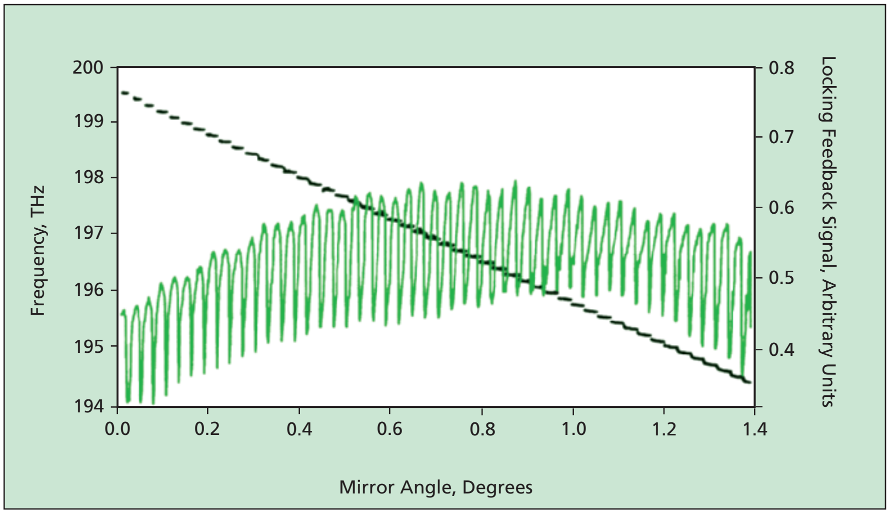
Discrete Wavelength-Locked External Cavity Laser

The laser is locked internally to frequencies of communication channels.

John H. Glenn Research Center, Cleveland, Ohio

A prototype improved external cavity laser (ECL) was demonstrated in the second phase of a continuing effort to develop wavelength-agile lasers for fiber-optic communications and trace-gas-sensing applications. This laser is designed to offer next-generation performance for incorporation into fiber-optic networks. By eliminating several optical components and simplifying others used in prior designs, the design of this laser reduces costs, making lasers of this type very competitive in a price-sensitive market.

Diode lasers have become enabling devices for fiber optic networks because of their cost, compactness, and spectral properties. ECLs built around diode laser gain elements further enhance capabilities by virtue of their excellent spectral properties with significantly increased (relative to prior lasers) wavelength tuning ranges. It is essential to exploit the increased spectral coverage of ECLs while simultaneously insuring that they operate only at precisely defined communication channels (wavelengths). Heretofore, this requirement has typically been satisfied through incorporation of add-in optical components that “lock” the ECL output wavelengths to these specific channels. Such add-in components contribute substantially to the costs of ECL lasers to be used as sources for optical communication networks. Furthermore, the optical alignment of these components, needed to attain the required wavelength precision, is a non-trivial task and can contribute substantially to production costs.



The **Frequency Varies in Steps** as a function of the mirror angle. Each step represents locking to the indicated frequency.

The design of the present improved ECL differs significantly from the designs of prior ECLs. The present design relies on inherent features of components already included within an ECL, with slight modifications so that these components perform their normal functions while simultaneously effecting locking to the required discrete wavelengths. Hence, add-in optical components and the associated cost of alignment can be eliminated.

The figure shows the locking feedback signal, and the frequency locking achieved by use of this signal, as a mirror is tilted through a range of angles to tune the ECL through 48 channels. The data for the frequency plot were obtained, simultaneously with the data for the locking-signal plot, by using a scanning Michelson interferometer to precisely determine the ECL wavelength (and, hence, frequency). Given the ability of the Michelson interferometer to obtain highly precise readings, the frequency plot can be taken to be a reliable indication of single-mode operation. The discontinuities in the frequency plot signify the switching of the ECL between channels; in other words, they indicate tuning with locking to discrete frequencies. The peaks of the feedback-locking signal correspond to the centers, or near centers, of the mirror angle scan through the corresponding channels. Thus, it is clear that when the feedback-locking signal is at a local maximum, the ECL is operating at single frequency at or near the middle frequency of the selected channel. This is all that is required for precisely locking the ECL output wavelength. The locking is achieved without additional external optical components.

Another aspect of the design of this ECL is a provision for the incorporation of a particularly simple microelectromechanical system (MEMS) mirror for wavelength tuning. The simplified motion of the mirror enables facile alignment and rapid tuning, both important in a network source laser. This ECL is capable of switching wavelengths across the entire frequency band indicated in the figure in a time of less than one millisecond. Other performance characteristics, like the side-mode-suppression ratio and relative-intensity noise, are equal to or better than those of other lasers now available.

This work was done by Jeffrey S. Pilgrim and Joel A. Silver of Southwest Sciences, Inc. for **Glenn Research Center**.

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17313-1.