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(54) **METHOD AND DEVICE FOR CAVITY ENHANCED OPTICAL VERNIER SPECTROSCOPY**

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See application file for complete search history.

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

4,791,633 A \* 12/1988 Esherick et al. .... 372/32  
2002/0171835 A1 11/2002 Haensch et al.

**OTHER PUBLICATIONS**

Thorpe, Michael J., et al., "Broadband Cavity Ringdown Spectroscopy for Sensitive and Rapid Molecular Detection", Science American Assoc. for the Advancement of Science, Mar. 17, 2006, vol. 311, p. 1595-1599.

Schliesser, Albert, et al., "Complete Characterization of a Broadband High-Finesse Cavity Using an Optical Frequency Comb", Optics Express, Jun. 26, 2006, vol. 14, No. 13, p. 5975-5983.

Scherer, James J., et al., "Broadband Ringdown Spectral Photography", Applied Optics, Dec. 20, 2001, vol. 40, No. 36, p. 6725-6732.

(Continued)

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(57) **ABSTRACT**

A spectroscopic analysis of a sample includes arranging the sample in a resonator cavity for transmitting cavity mode frequencies with a cavity mode frequency spacing, coupling pulsed source light into the resonator cavity, with the source light including source comb frequencies with a source frequency spacing, coupling pulsed transmitted light out of the resonator cavity, and spectrally resolved detecting the transmitted light with a detector device. The cavity mode frequency spacing and the source frequency spacing are detuned relative to each other, so that the transmitted light includes transmitted comb frequencies with a spacing larger than the source frequency spacing. The detecting feature includes collecting spectral distributions of the transmitted light in dependence on relative positions of the cavity mode frequencies and the source comb frequencies. The cavity mode frequencies and the source comb frequencies are varied relative to each other and different transmitted comb frequencies are individually resolved.

**31 Claims, 3 Drawing Sheets**

