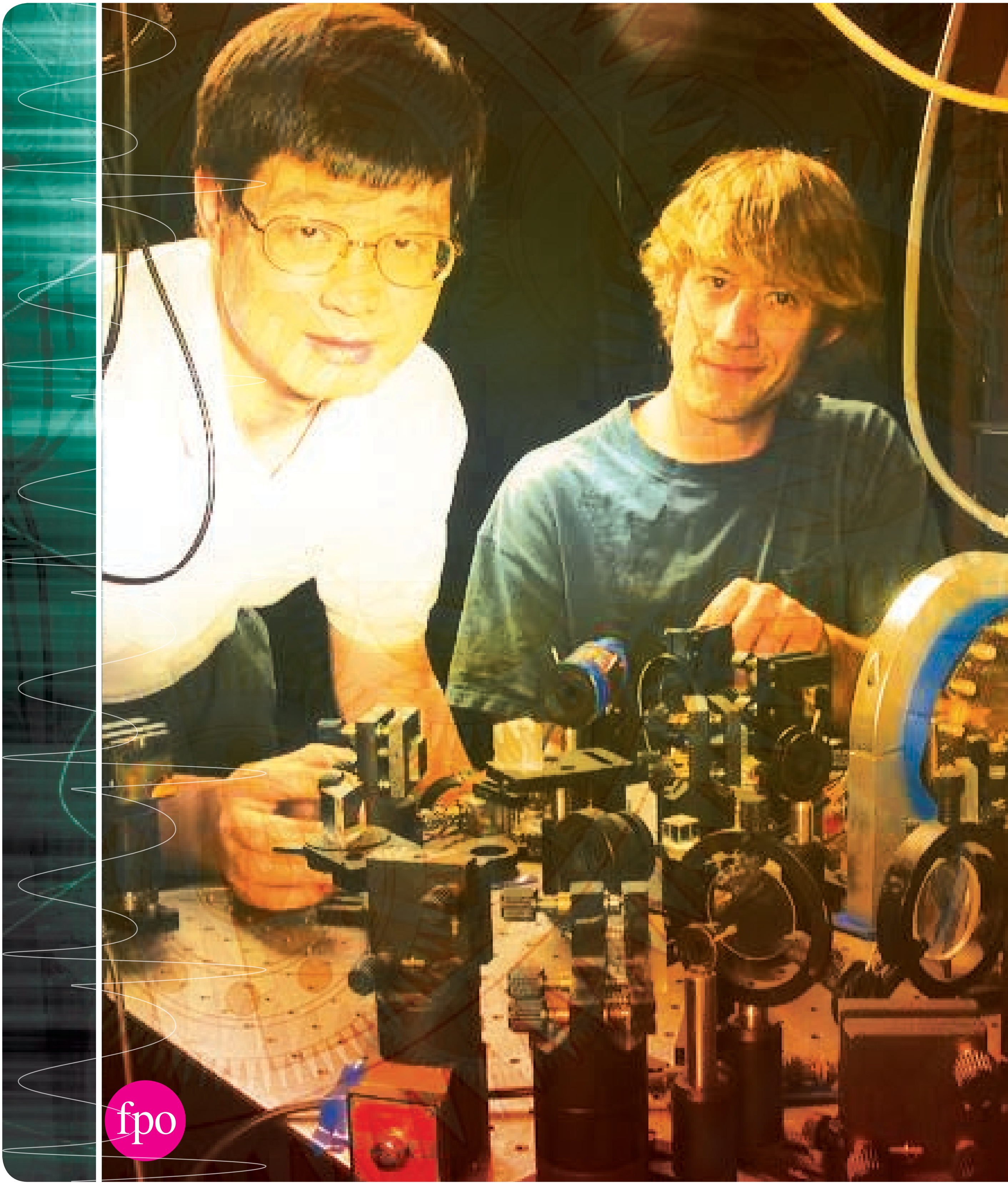
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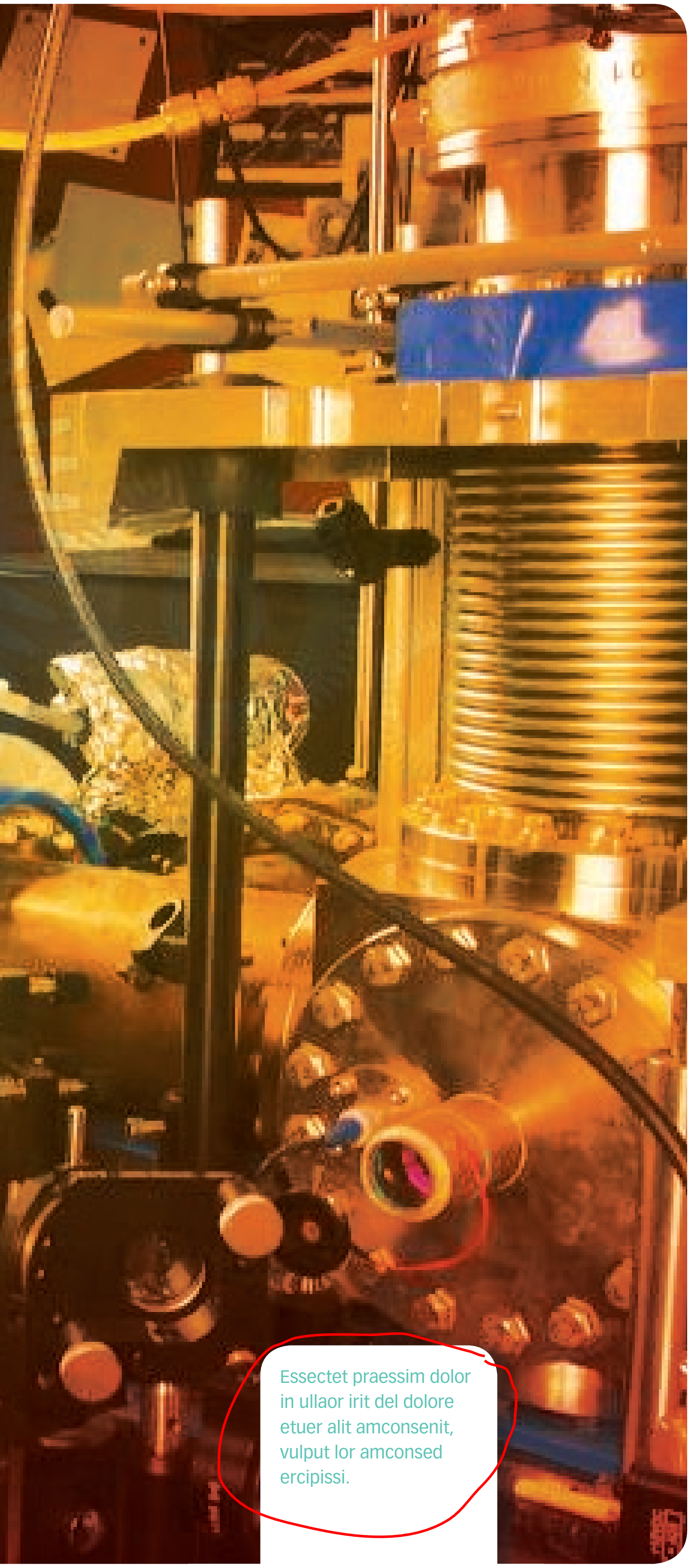

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A MATTER OF LIGHT AND BREATH

New technology detects disease in your breath

By Pam Johnson

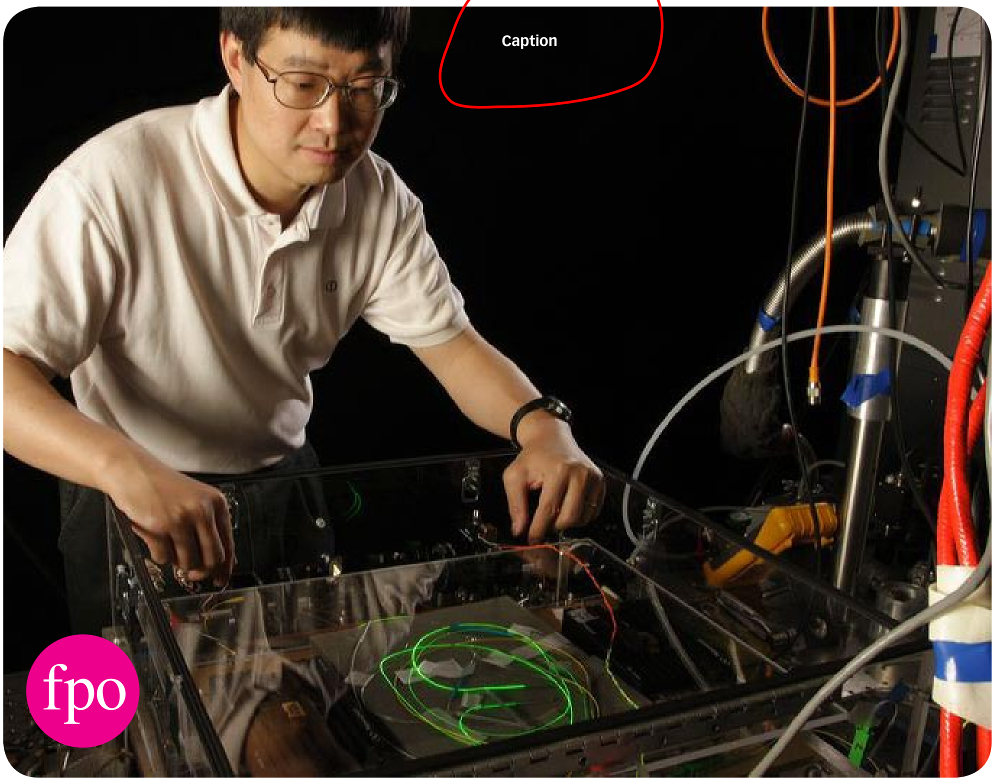
Photography by Bob Torrez

Harnessing the interaction of light and matter using ultrafast laser light appears not to be a topic relevant to dentistry, but physicist Jun Ye, a who leads the AMO Physics and Precision Measurement research group at JILA (see sidebar "What is JILA?" page xx.) at the University of Colorado in Boulder has discovered a technique that may have far-reaching diagnostic possibilities for medicine, the field of dentistry, and beyond. By blasting a person's breath with laser light, molecules that may be biomarkers for disease can be detected simultaneously.

This discovery was not the main focus of Ye's research group; they have been working on developing the next generation of atomic clocks where the tick of the clock is represented by the waves of stable laser light. However, finding such a practical application as a result of ongoing fundemental research pleases Ye. This discovery may someday allow doctors even dentists to screen and monitor patients in real-time for a variety of diseases by simply and non-invasively sampling their breath.

Power of laser light

Ye's technique uses different frequencies of infrared laser light to identify trace levels of different molecules at the same time. Because different molecules absorb light at specific frequencies, it is possible to establish a pattern of light frequen-



Caption

cies that form a "signature" marker for identifying what those molecules are and at what concentration. Known as optical frequency comb spectroscopy, the technique is powerful enough to distinguish rare molecules that may be biomarkers for specific diseases.

The optical frequency comb laser is a very precise tool for meausuring different colors or frequenceis of light. Each comb line, or "tooth" is tuned to a distinct frequency of a particular molecule's vibration or rotation, and the comb covers a broad spectral range--much like a rainbow of color--that can identify thousands of individual molecules. Ye likens the concept to turning the dial on a radio to pick up different radio stations broadcasting on separate radio frequencies.

You are what you exhale

When breathing, you inhale a complex mixture of gasses from the air including oxygen, carbon dioxide, nitrogen, carbon monoxide, water vapor and a rich mixture of other gases. Typical exhaled breath contains less oxygen, more carbon dioxide, and a collection of more than a thousand varieties of other chemical molecules, most of which are present in only trace amounts. These trace amounts of ammonia, methane or acetone are precisely what Ye is looking for. In certain concentrations they may be the biological fingerprint of a disease like renal failure, liver and kidney disease, diabetes, or even periodontal disease.

Prior to Ye's use of optical frequency comb spectroscopy, breath analyzing equipment could only detect one biomarker at a time such as ammonia. However, the presence of a single species of molecules in the breath could be an indicator of a number of different diseases. The ability to analyze a broad spectrum of compounds in the breath simultaneously and interpret the complexity and composition of their makeup allows efficient and reliable analysis and diagnosis in pinpointing a particular disease.

> **"OUR RESEARCH IS UNDERTAKEN AT THE ABSOLUTE FRONTIERS OF LIGHT AND MATTER INTERACTION."**

"The amount of information gathered with this approach was previously unimaginable," commented Ye. "It's like being able to see every single tree of an entire forest. "

To use the device, a person breathes into a tube into which a laser is shining. Mirrors positioned around the tube reflect the laser light many times through the breath sample to enhance the detection of the sensitivity of compounds. The laser signal bounces off the different chemicals in the breath sample, and the device detects the unique light signals of specific compounds.

The future

Ye's discovery has yet to be tested in clinical trials but already a number of companies have contacted him about their interest in commercial development of his laser technique for use with patients. The technology may have other important applications such as in chemistry labs, environmental monitoring stations, security screening sites, even wineries, anywhere monitoring the air is an important element to the safety of the product or population.

For medical and dental uses, much work remains to be done. There are few, if any, catalogued benchmarks or biomarkers for diseases. Research still needs to be done on the specific biomarkers for healthy individuals, individuals with each disease, different stages of that disease, and biomarkers relevant to patient age and gender.

What is most exciting to Ye is that this technology has the potential to be used for very early detection of health problems long before any symptoms are noticeable to the patient.

What is JILA?

JILA (jilawww.colorado.edu) is a joint institute of the National Institute of Standards and Technology (NIST), a non-regulatory agency of the U.S. Department of Commerce, and the University of Colorado at Boulder. Founded in 1962, JILA is one of the nation's leading research institutes in the physical sciences.The institute's scientific research encompasses seven categories: astrophysics, atomic and molecular physics, biophysics, chemical physics, nanscience, optical physics, and precison measurement. lab