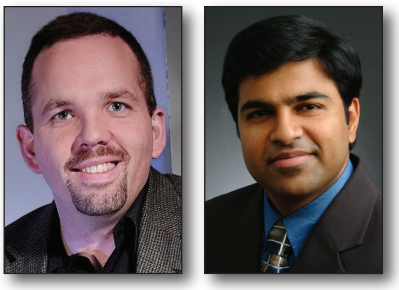
Interview with **David Hilton, MS, PhD**
Laser Physicist (left)

Interview conducted by **Ash Vasanthan, DDS, MS**
Associate Editor (right)



A Chat with Laser Physicist, DAVID J. HILTON, MS, PhD

Dr. Vasanthan (V): ***What is the physics behind lasers? What makes lasers so unique compared to any other light source?***

Dr. Hilton (H): A laser is a controlled light source. Lasers have, in most cases, fixed operating wavelengths that are determined by the specific laser type (Nd:YAG, Diode, Er:YAG, Er:YSGG, CO_2, etc.), which permit the operator to specifically target tissue that absorbs at that wavelength. They also produce light in one direction to form a beam, in contrast to a light bulb that radiates light in all directions. As a result, it is possible to focus the emitted light from a laser to a small spot using a lens and to deliver its energy to cut tissue, remove hard tissues or accretions or to kill bacteria. Finally, lasers are *coherent* sources of light; this means that two interacting laser beams form an interference pattern where two different light bulbs, in general, do not.

V: ***What is the difference between the laser used in a regular pointer for lectures compared to the one used in medicine/dentistry?***

H: The major difference is the laser power. As a laser pointer, you want a *compact* device that can be run off of AA or AAA batteries for an extended period of time. For medical/dental applications, the laser power may need to be higher to cut tissue, kill bacteria or remove dental calculus. If they are ANSI Class 3B or Class 4 lasers, you and your patient(s) will need to wear laser goggles to operate the laser safely, as these lasers are *easily* capable of causing eye damage. All lasers used in dentistry fall under class 3B and 4.

V: ***There is a big discrepancy in the size of the laser equipment with some being very small and others being quite big. Why is there a difference?***

H: Power, again, is the main difference. A laser pointer need not produce much light to do its job, while a laser that would be used to cut steel must produce a tremendous light output. For medical and dental applications, the required power is often times rather modest, especially if the beam is focused onto the tissue.

V: ***Currently there are a lot of different lasers being used in dentistry: CO_2, Diode, Nd: YAG, Er: YAG. How does each one differ?***

H: The actual atom or molecule used to generate the light determines the operating laser wavelength. For example**, carbon dioxide** lasers generate light from transitions between different molecular vibrational and rotational states and emit light at a wavelength of either 9.6 or 10.6 µm. **Diode lasers** are also very common and generally emit in the near infrared (980 nm is one common wavelength for a gallium arsenide diode laser). In a **Nd:YAG** laser, the neodymium (Nd) atom is emits laser light at 1064 nm; this wavelength corresponds to one of the atom's electronic transitions. **Er:YAG** is a similar laser that uses the YAG crystal to manage heat flow and the erbium (Er) atom to generate light emission at 2940 nm. The related Er:YSSG laser emits 2790 nm, again due to the Er atom in the YSSG host.

The use of lasers in periodontal treatment is also growing, primarily for the laser's ability to focus on the infected areas under the sensitive gingiva and sterilize them.

V: ***Wavelength is always cited to be an important factor for a laser. Why is that?***

H: Materials absorb different wavelengths, depending on their chemical components. To target a specific tissue, we need to understand its chemistry and how it will absorb the laser light. The Nd:YAG laser operates at 1064 nm, which is strongly absorbed by body tissues and hence is more useful for use with soft tissues. The Er:YAG laser operates at 2940 nm and can be used to drill enamel, hydroxyapatite, or other hard tissue. The advantage over a conventional drill to prepare a tooth for filling is the ability to target a small area (the cavity) with nearby areas experiencing little to no damage. As a second effect, since the Er:YAG and Er:YSGG lasers are strongly absorbed by water, the water in bacteria will also absorb energy. The right dose will heat the bacteria to a high enough temperature where it dies, thus sterilizing the surface of the tooth while the laser drills away the damaged tissue.

V: ***Is it true that a laser can destroy bacteria only based on direct contact?***

H: The use of lasers in periodontal treatment is also growing, primarily for the laser's ability to focus on the infected areas under the sensitive gingiva and sterilize them. The Nd:YAG, Er:YAG and Er:YSGG are strongly absorbed by water, so any bacteria within the beam focus will absorb this energy. The majority of this energy would be turned into heat and, if the temperature change is large enough, kill the bacteria. This can generally be done at a laser power without much damage to the underlying enamel and bone.

V: ***Can a laser effectively remove calculus (an accretion of calcium and phosphate with bacteria) attached to the root surface of a tooth (made of calcium and phosphate with some organic matter)?***

H: Well, automobile manufacturers regularly use lasers to cut steel, so the main issue is not removing calculus, but doing so in a way that preserves the existing tissue/bone. The Er:YAG laser is specifically absorbed by hydroxyapatite, so it will be absorbed by both the calculus and the tooth. However, at the right power (which may be a very narrow range) calculus would be loosened, although there is a risk of root surface damage.

> *There has been and will continue to be an enormous investment in developing laser technology for a wide range of industries.*

V: ***Based on your work with the industry and lasers where do you see the future of lasers in our applications in dentistry?***

H: There has been and will continue to be an enormous investment in developing laser technology for a wide range of industries and for a wide range of medical applications. Our ability to develop new materials that emit at specific wavelengths will allow us to more carefully target specific kinds of bacteria and surface buildup. We will also likely see increased use of lasers as *diagnostic* tools. There has been some preliminary work that uses very long wavelength lasers for caries detection (J. Biomed. Opt. 8, 303 (2003); Caries Res 2003;37:352–359). Since these long wavelengths are non-ionizing, they are safer than traditional x-rays for both patients and the dental staff. These long wavelengths have also been shown to be able to discriminate between normal and cancer cells in topical skin cancers (Brun et al. Physics in Medicine and Biology (2010) vol. 55 pp. 4615); it may be possible to apply this in the future to oral cancer detection to permit preliminary diagnosis prior to performing a biopsy. ■

Dr. David J. Hilton *obtained a B.S. and M.S. (1999) in Optics from the University of Rochester and M.S. (2001) and Ph. D. (2002) in Applied Physics from Cornell University. He is currently an Assistant Professor of Physics at the University of Alabama at Birmingham. His research focuses on the development and utilization of laser and other coherent light sources for solid-state materials characterization, quantum control, and biomedical applications.*

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