Light Syringes

Scared of needles? Fear no more! A new injection technique could make the needle obsolete by replacing it with a flash of light.

No one likes having an injection. The idea of a needle puncturing one's skin is indeed dreadful. A recent technology, developed by Jack Yoh and colleagues from Seoul National University in South Korea, may soon allow us to replace needles with laser pulses.

Some drugs and vaccines need to be carefully injected inside a certain part of the human body. Clearly, a reliable control over the dose, the timing and the place of the application is highly desirable both for the patient's safety and the treatment success. Even though various techniques have been developed, at the moment nothing seems better than the use of syringes to administer the right dose just where and when it is needed. Unfortunately, the sheer idea of needles tends to scare people away from necessary medical treatments.

Can we replace needles with something more comfortable? The *biolistic* process — a contraction of *bio-ballistic* — does just that. In a nutshell, drug microparticles are shot into the tissue precisely where they are needed. This does, however, pose the problem of accelerating such a particle to just the right speed so that it can penetrate into the tissue to the desired depth. Unfortunately, the techniques proposed until now [1,2], even though successful in the lab, are not likely to make it to the clinical trials because they use small explosive charges or gases to accelerate the particles.

In 2005, Menezes and Takayama proposed a technique to inject microparticles using laser ablation [3]. The particles to be injected are deposited on one side of a thin metallic foil. When a focused laser pulse is shot on the other side, some of the metal gets immediately vaporized and transformed into a plasma, which expands supersonically creating a shock wave, similar to the one produced by a supersonic jet. The foil instantly becomes deformed and consequently the particles are ejected at speed as high as 20 000 km/h. At this speed, they can easily penetrate into the human skin without damage or pain.

Yoh and colleagues have now managed to control the depth of the injection by tuning the laser pulse energy. In this way, particles were accurately injected 1-2 mm into a gelatin-water solution, which mimics a human tissue. "The precise control of dose and depth of penetration without the use of a needle is the major strength of our device," says Yoh. They have also been able to control the injection of liquid drugs by creating microjets. "Microparticle penetration is a great idea," explains Yoh, "but microjet injection is a better way of delivering drug transdermally?. The diame-

Figure 1: An artistic view of a light syringe. Energetic laser pulses may soon become a painless means to administer drugs directly into tissues.

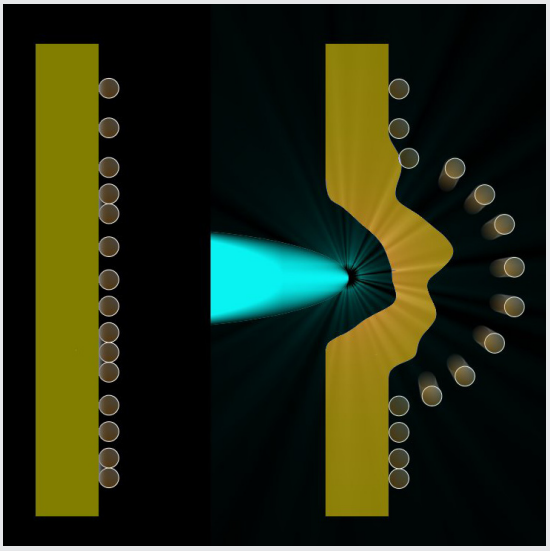

Figure 2: Particle ejection by laser ablation. Microparticles are deposited on a thin metallic foil (left). When a short but energetic laser pulse is focused on one side of the foil, a shock wave propagates supersonically and the particles are ejected at speeds up to 20 000 km/h (right).

ter of our current microjet is about 100 μm which is only half the size of the thinnest needle available. In this way, the chance of hitting the pain sensory is significantly reduced."

The next step – to test the technique on animal tissues – is now underway. As Yoh says, "we are now shooting animal tissue (commercially bought pork fatty tissue)." After that, Yoh is already planning to commercialize his new device. "We are working towards obtaining Food Drug Administration approval and, ultimately, we would commercialize the device for painless injection for all."

Unfortunately, it will take time before we are able to forget about the physical and psychological pain associated with needles. But the good news for all who fear needles is that the outlook for the future appears positive. "I believe the technique will work," comments Claude Phipps from Photonic Associates, LLC, Santa Fe, Minnesota, USA, "Yoh is using a[n established] concept in a creative, novel application."

[1] T. M. Klein, E. D. Wolf, R. Wu, and J. C. Sanford, *High-velocity microprojectiles for delivering nucleic acids into living cells*, Nature **327**, 70–73 (1987).

[2] N. J. Quinlan, M. Kendall, B. J. Bellhouse, and R. W. Ainsworth, *Investigations of gas and particle dynamics in first generation needle-free drug delivery devices*, Shock Waves **10**, 395–404 (2001).

[3] V. Menezes and K. Takayama, *Laser-ablation-assisted microparticle acceleration for drug delivery*, Appl. Phys. Lett. **87**, 163504 (2005).

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Tae-hee Han, Ardian B. Gojani & Jack J. Yoh, **Biolistic injection of microparticles with high-power Nd:YAG laser**, Applied Optics (2010) **49**, 3035-3041.

Tae-hee Han & Jack J. Yoh, **A laser based reusable microjet injector for transdermal drug delivery**, Journal of Applied Physics (2010) **107**, 103110.