

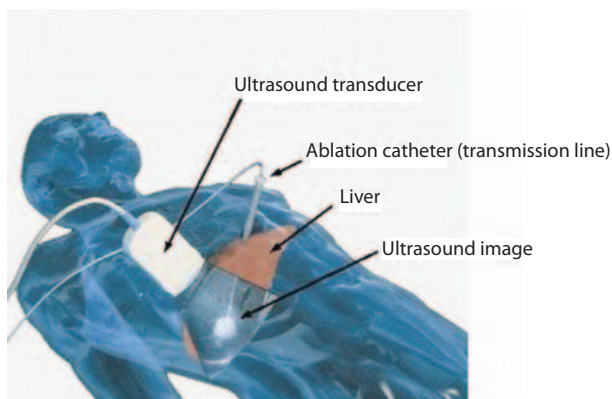
## Technology Brief 4: EM Cancer Zappers

From laser eye surgery to 3-D X-ray imaging, EM sources and sensors have been used as medical diagnostic and treatment tools for many decades. Future advances in information processing and other relevant technologies will undoubtedly lead to greater performance and utility of EM devices, as well as the introduction of entirely new types of devices. This technology brief introduces two recent EM technologies that are still in their infancy, but are fast developing into serious techniques for the surgical treatment of cancer tumors.

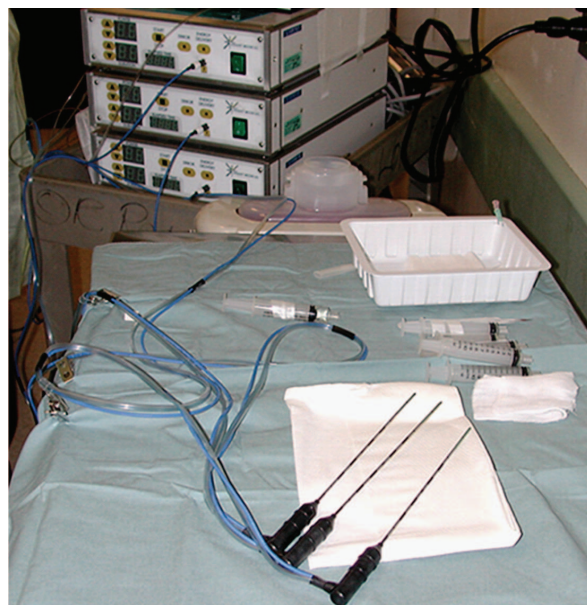
### Microwave Ablation

In medicine, **ablation** is defined as the “surgical removal of body tissue,” usually through the direct application of chemical or thermal therapies. Microwave ablation applies the same heat-conversion process used in a microwave oven (see Technology Brief 3), but instead of using microwave energy to cook food, it is used to destroy cancerous tumors by exposing them to a focused beam of microwaves. The technique can be used percutaneously (through the skin), laparoscopically (via an incision), or intra-operatively (open surgical access). Guided by an imaging system, such as a CT scanner or an ultrasound imager, the surgeon can localize the tumor and then insert a thin coaxial transmission line ( $\sim 1.5$  mm in diameter) directly through the body to position the tip of the transmission line (a probe-like antenna) inside the tumor (Fig. T4-1). The transmission line is connected to a generator capable of delivering 60 W of power at 915 MHz (Fig. T4-2).

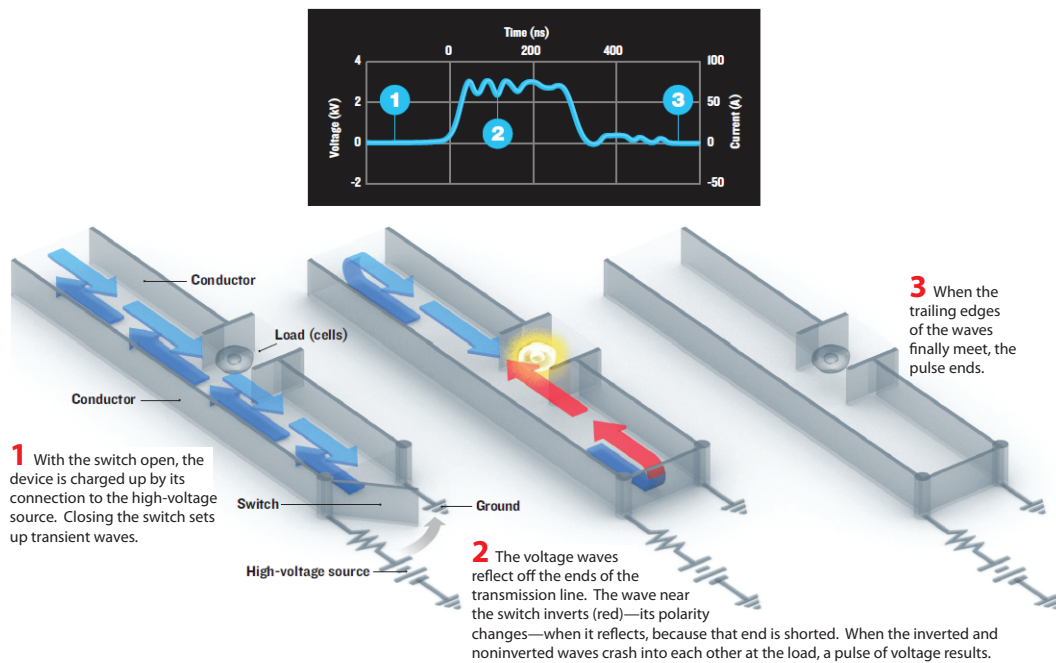
The rise in temperature of the tumor is related to the amount of microwave energy it receives, which is equal to the product of the generator’s power level and the duration of the ablation treatment. Microwave ablation is a promising new technique for the treatment of liver, lung, and adrenal tumors.



**Figure TF4-1:** Microwave ablation for liver cancer treatment.



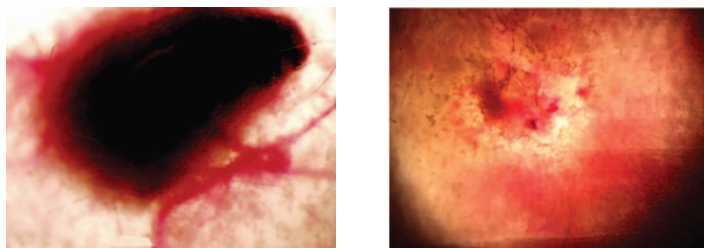
**Figure TF4-2:** Photograph of the setup for a percutaneous microwave ablation procedure in which three single microwave applicators are connected to three microwave generators. (Courtesy of *RadioGraphics*, October 2005, pp. 569–583.)



**Figure TF4-3:** High-voltage nanosecond pulse delivered to tumor cells via a transmission line. The cells to be shocked by the pulse sit in a break in one of the transmission-line conductors. (Courtesy of *IEEE Spectrum*, August 2006.)

## High-Power Nanosecond Pulses

*Bioelectrics* is an emerging field focused on the study of how electric fields behave in biological systems. Of particular recent interest is to understand how living cells might respond to the application of extremely short pulses (on the order of nanoseconds ( $10^{-9}$  s), and even as short as picoseconds ( $10^{-12}$  s) with exceptionally high voltage and current amplitudes. The motivation is to treat cancerous cells by *zapping* them with high-power pulses. The pulse power is delivered to the cell via a transmission line, as illustrated in Fig. T4-3. Note that the pulse is about 200 ns long, and its voltage and current amplitudes are approximately 3,000 V and 60 A, respectively. Thus, the peak power level is about 180,000 W! However, the total energy carried by the pulse is only  $(1.8 \times 10^5) \times (2 \times 10^{-7}) = 0.0036$  Joules. Despite the low energy content, the very high voltage appears to be very effective in destroying malignant tumors (in mice, so far), with no regrowth (Fig. T4-4).



**Figure TF4-4:** A skin tumor in a mouse before (top) and 16 days after (bottom) treatment with nanoseconds-long pulses of voltage. (Courtesy of *IEEE Spectrum*, August 2006.)