Electrically Isolated Power Delivery for MRI Applications

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Problem

Conventional means of powering electronic devices in high magnetic fields using copper wire have inherent limitations including the potential for electromagnetic interference, conductive grounding effects, crosstalk between power cables, and the risk of RF burning of patients. Photonic power, the creation of electrical power from laser light delivered over fiber, offers the promise of driving electronics in high magnetic fields with complete electrical isolation. Optical energy for pre-amplifiers, low-power transmitters, sensors, gauges, switches and relays can be efficiently delivered through noise immune and non-conductive optical fiber.

Methods

The R&D objective was to produce a photovoltaic power converter (PPC) fabricated entirely of non-magnetic material to deliver approximately 500 milliwatts of power to electronics such as RF amplifier/coil assemblies and video cameras. In addition, testing was conducted to demonstrate fully isolated power delivery in a high magnetic environment. By illuminating the PPC with laser diode light delivered over fiber, optical energy can be converted to electrical power. An AlGaAs/GaAs-based PPC, as shown in Figure 1, is composed of several p-n junctions that are connected in series such that the voltages from each junction are added. Current is directly proportional to the optical light illuminating the chip. The challenge for operation in high magnetic fields is to fabricate the PPC completely of non-magnetic material to maintain a uniform magnetic field.

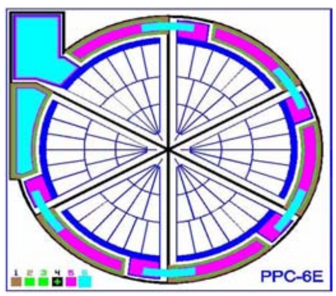

Figure 1. 6 Volt Photovoltaic Power Converter Chip

Results

The PPC shown in Figure 2 is comprised of a GaAs chip packaged in a non-conductive ceramic housing with the output leads made of gold-plated brass. The PPC demonstrated efficiencies of approximately 40% when driven by a 1 watt laser over 62.5 μm fiber. Figure 3 demonstrates the efficiencies achieved for various levels of light illumination. Interestingly, the ceramic housing also provided improved heat transfer and permitted slightly higher peak powers to be achieved than is possible with a metallic package. Electronics such as RF amplifiers were powered in the presence of electromagnetic fields with strengths up to 2.5 Tesla without any degradation in performance and without the generation of excess noise and EMI.

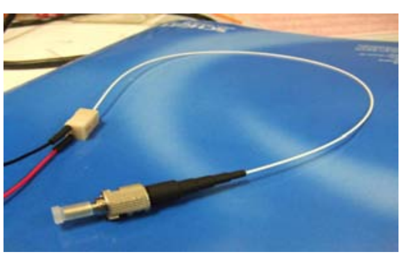

Figure 2. Non-magnetic Pigtailed PPC

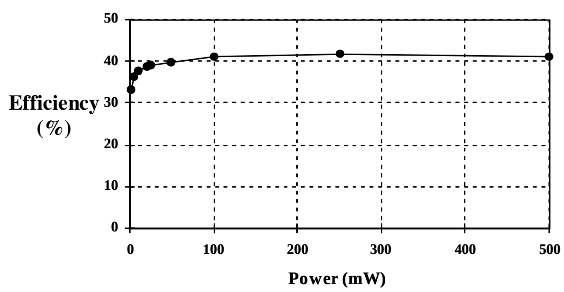

Figure 3. PPC Efficiency vs. Light Illumination

Conclusions

The electrical isolation offered by photonic power provides the potential for enhanced imaging through the use of more closely spaced coil arrays, and the capability to power many other types of electronics in high magnetic fields.