Scientists fabricate first plasma transistor

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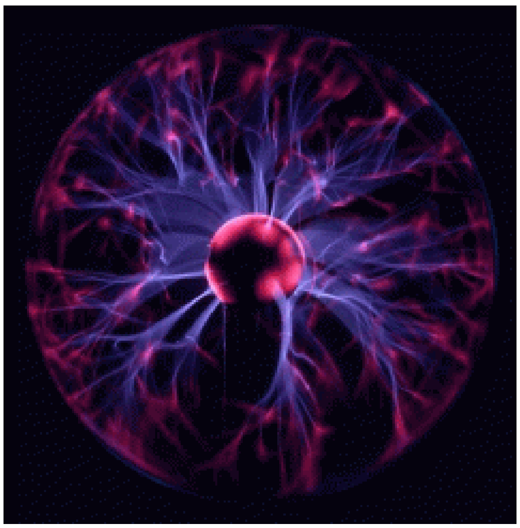

A plasma lamp contains a partially ionized gas. For the first time, researchers have fabricated a plasma transistor (not shown). Image credit: Luc Viatour.

Since their development in the 1940s, transistors have been at the heart of computers and other modern electronic devices. Transistors - whose job is to start, stop, or amplify electric current - come in all shapes, sizes and materials, depending on the application. Recently, scientists have fabricated a new variation: a micro-sized plasma transistor.

Researchers at the University of Illinois at Urbana-Champaign developed the microplasma transistor by integrating a conventional microcavity plasma device with an electron emitter. Kuo-Feng (Kevin) Chen and Professor J. Gary Eden, Director of the Laboratory for Optical Physics and Engineering, published their study in a recent issue of

Applied Physics Letters. As Eden explained, a plasma transistor could one day have certain advantages compared with conventional transistors.

“As you might imagine, this first plasma transistor has not yet been engineered to the degree necessary for a commercial product,” Eden told *PhysOrg.com*. “Nevertheless, it should be mentioned that a microplasma transistor is advantageous in those situations requiring the transistor to handle high voltages and power. Unlike conventional transistors that can be damaged by a voltage transient, for example, the microplasma transistor is expected to be quite rugged because a gas (and plasma) cannot be ‘burnt.’”

In the plasma transistor, the electron emitter injects electrons in a controlled manner into the sheath of a partially ionized neon gas (the plasma). The scientists discovered that even a voltage as low as 5 volts can change the properties of the microplasma, including quadrupling the current and increasing the visible light emission.

By controllably altering the microplasma’s properties, the electron emitter effectively transforms the plasma microcavity device into a three-terminal transistor. Like a regular transistor, the microplasma transistor has the ability to control the current traveling through the terminals, and act as a switch or amplifier.

The scientists began investigating the plasma transistor while trying to solve a problem that arises in plasma devices, such as those in plasma TV displays. In such devices, scientists have limited control over electron production in the plasma sheath, in which current flow is normally dominated by ions. The result is that these plasma devices require high voltages to operate. In an attempt to lower the required voltage and increase efficiency, Chen, Eden, and others have been investigating methods of generating additional electrons, such as by growing electron-emitting carbon nanotubes on the inside wall of the microplasma device, as in a previous study.

In the current study, the auxiliary electrons provided by the electron emitter filled the role of injecting electrons into the plasma sheath, thereby reducing the required voltage. But because the electron source is also controllable, the scientists could modulate the plasma's conductive properties, as well. As the main component of the plasma transistor, the plasma sheath is analogous to the base of a conventional transistor.

Besides controlling the current and visible light emission, the scientists could also reduce the ratio of ion-to-electron density at the edge of the sheath of the device. In addition, injecting electrons into the plasma sheath provides a way to estimate the electron density in the sheath without the need for an internal probe.

"With regard to potential applications of microplasma transistors, the most attractive near-term opportunity is possibly for high-resolution displays for cell phones or portable DVD players," Eden said. "Other interesting applications include environmental sensors (producing plasmas in air samples and detecting light produced by pollutants) and biomedical diagnostics."

More information: Chen, K.-F. and J. G. Eden. "The plasma transistor: A microcavity plasma device coupled with a low voltage, controllable electron emitter." *Applied Physics Letters* 93, 161501 (2008).