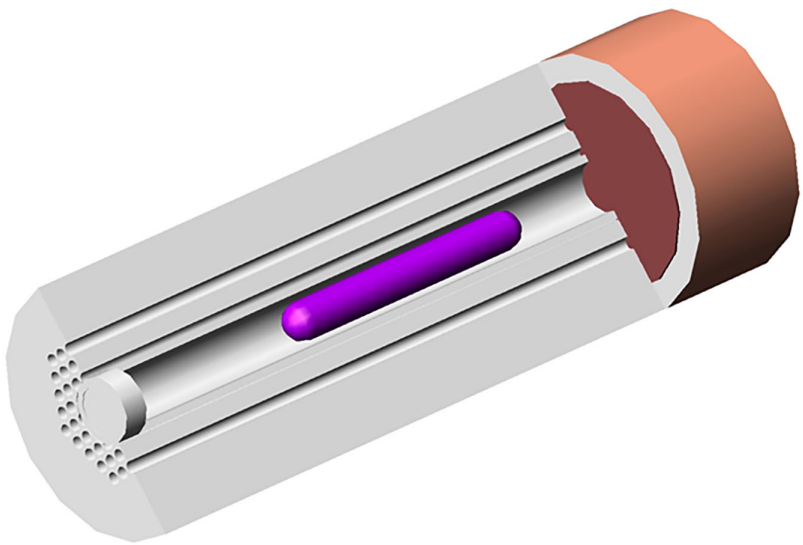


National Aeronautics and
Space Administration

TECHNOLOGY SOLUTION

Optics

Hollow-Core Fiber Lamp

A mass-producible hollow-core photonic crystal fiber lamp for mercury ion clocks

NASA's Jet Propulsion Laboratory (JPL) has developed a hollow-core photonic crystal fiber (HCPCF) mercury lamp that generates higher intensity light for mercury ion clocks. While the outstanding long-term stability of ground-based mercury ion clocks has attracted significant interest, conventional plasma discharge lamps limit the short-term stability of the clock because they do not output sufficient ultraviolet (UV) light. In the HCPCF lamp, plasma is generated along the length of the fiber and excited by a coil, producing UV light. The longer the fiber, the more light is generated; this increases the clock signal-to-noise ratio and leads to an improvement in clock short-term stability. Unlike conventional plasma discharge lamps, HCPCF lamps are mass-producible, meaning that they can be fabricated in a repeatable manner that allows for standardization of these optical sources.

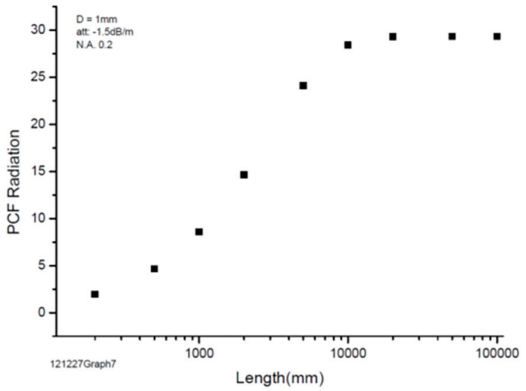
BENEFITS

- Higher intensity light generation improves the short-term stability of mercury ion clocks
- HCPCF lamps can be fabricated in a repeatable manner, allowing for standardization of these optical sources

THE TECHNOLOGY

One end of JPL's HCPCF is fused with a piece of deep-UV fiber with a similar cladding diameter; both fiber types work at 194 nm. The other end of the HCPCF is attached to an ultrahigh vacuum system for lamp fabrication and mercury vapor is injected into the air core of the fiber with argon as a buffer gas. The HCPCF is heated near the vacuum side by a flame torch to seal the mercury and argon inside the fiber, and then the completed lamp is pinched off from the vacuum system. Light fulfilling the numerical aperture of the fiber can be collected along the fiber. The longer the fiber, the more light will be collected and output for use in mercury ion clocks and other applications. Since the HCPCF serves as both a plasma generator and a UV waveguide, the light output is orders of magnitude more intense than the light output of conventional mercury plasma discharge lamps.

An HCPCF lamp has been demonstrated using a commercial HCPCF at a visible wavelength. HCPCFs at deep-UV wavelengths are not available commercially at this time.



Radiation collected by the HCPCF as a function of fiber length with fixed 1.5 dB/m attenuation. Within 10 m, the radiation is no limited by the attenuation.

APPLICATIONS

The technology has several potential applications:

- Optical systems for ground-based mercury ion frequency standards - timekeeping, metrology
- Micro-plasma research - lithography, nanomaterial synthesis, thin-film coating, medicine

PUBLICATIONS

Patent No: 9,372,299

technology.nasa.gov

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More Information

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