Plasma for medical and biological uses: New electron density diagnostic method

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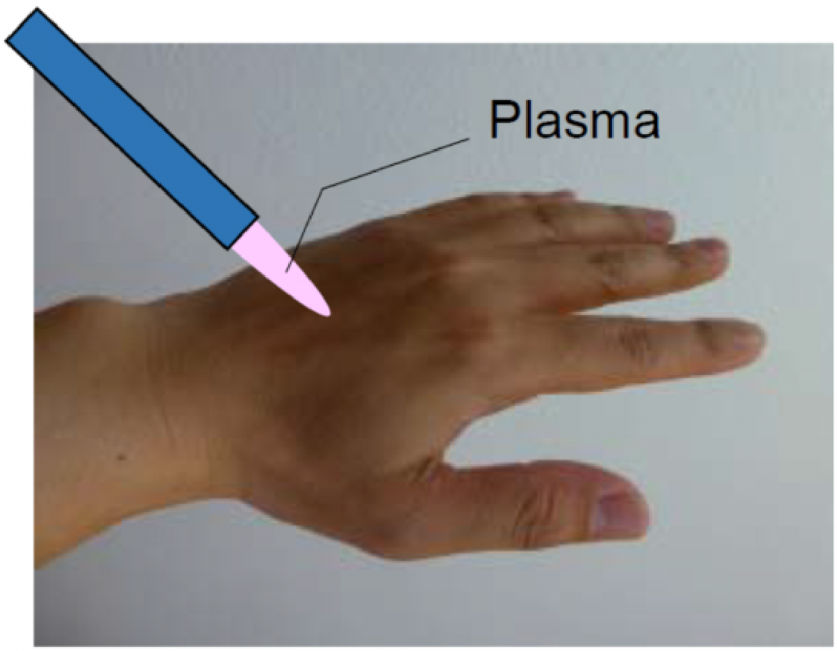


Atmospheric-pressure low-temperature plasma for medical application. Credit: NINS/NIFS

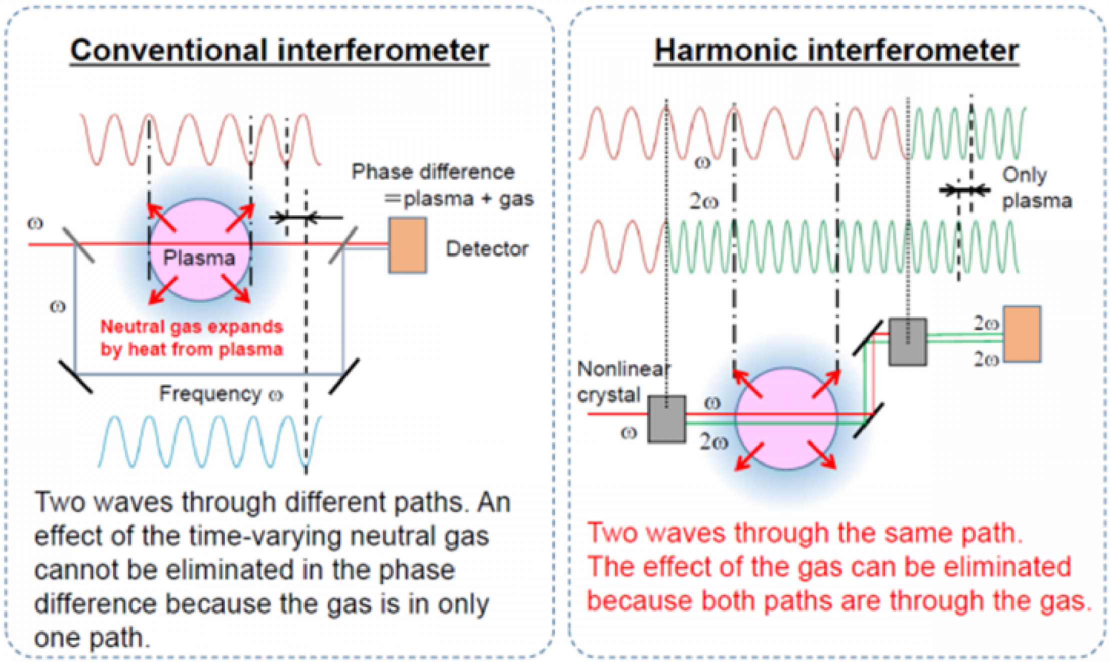
The National Institutes of Natural Sciences, National Institute for Fusion Science and The University of Tokyo Graduate School of Frontier Sciences Department of Advanced Materials Science research group have developed an electron density diagnostic method for atmospheric pressure low-temperature plasma that is anticipated to be applicable for the fields of environmental protection and of medicine and biology. Diagnostics techniques for fusion plasma research are applied to this achievement and make it possible to diagnose electron density using an interferometer, which in the past had been difficult due to influences from the atmosphere.

Applied research of atmospheric pressure low-temperature plasma in environmental protection that decomposes hazardous materials and in the fields of medicine and biology (for example, Image 1) is being conducted around the world. In order to produce plasma appropriate for each field, it is necessary to precisely measure the plasma's physics quantities and to control the plasma parameters. Electron density is one of the fundamental physics quantities, and to date various measurement methods have been used. Interferometry, which uses a laser beam, is the representative electron density diagnostic method. But in the case of atmospheric pressure low-density plasma, due to the influences of changes in the atmospheric pressure in a plasma as well as around the plasma, it was difficult to accurately measure electron density.

On the other hand, in magnetic field confinement fusion plasma intended for a fusion reactor, which research is being conducted at the National Institute for Fusion Science, development of high precision electron density measurements is becoming an important research topic.

Through experiments utilizing the Large Helical Device at the National Institute for Fusion Science, we have developed a dispersion interferometer (harmonic interferometer) which makes possible the measurement of a plasma's electron density with high accuracy. Using this method that has been developed by high-temperature plasma diagnostics, as shown in Image 2, we have succeeded in greatly reducing the influence of atmospheric pressure (gas), which was a problem in high-accuracy measurement of atmospheric pressure low-temperature plasma. Through this success, we demonstrated that we can measure electron density with higher accuracy than previous interferometers and also comparatively easily.

By being able to measure electron density with high accuracy in atmospheric pressure low-temperature plasma, it is no longer necessary to rely solely upon experience and trial and error. We can produce plasmas that are optimal for application in the fields of medicine and biology. Further, by being able to precisely measure electron density, it will now be possible to clarify through computer simulation the important behaviors of active ion species that play important roles in their interaction with living organisms and materials hazardous to the environment. The measurement method using the harmonic interferometer that we have developed does not depend upon gas composition used when plasma is produced, as compared to other electron density diagnostic methods for atmospheric pressure low-temperature plasma. There also is the advantage that high-accuracy electron density can be measured. Based upon this, we look forward to great acceleration of both the fundaments and the application of atmospheric pressure low-density plasma research.



Reduction in influence of atmospheric pressure (gas) with harmonic interferometer. The interferometer can obtain information (density, etc.) of the medium from the time (phase) difference between two waves. Credit: NINS/NIFS

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