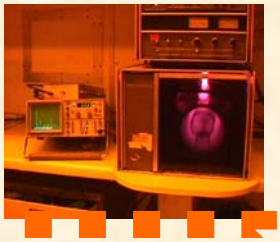
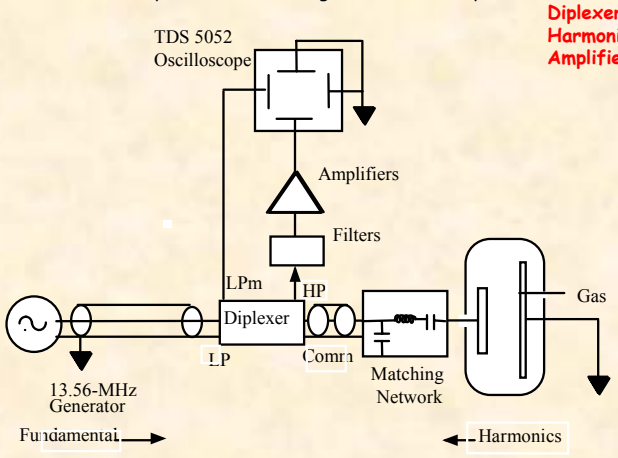
Plasma Harmonics Lissajous Measurements

S.Bergamini*, V. Law*, T. Kenyon*, N. Thornhill*, L. Lea**.
*Electronic & Electrical Engineering
University College London, Torrington Place WC1E 7JE London (UK)
** STS-plc Newport, Gwent, Wales NP1 9UJ UK

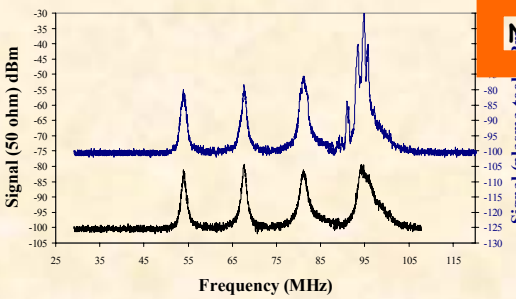


The instrument

Non-invasive analogue instrument for real-time detection of plasma generated harmonics of the fundamental drive frequency of 13.56 MHz. It allows the simultaneous measurement of the amplitude and relative phase of incident and plasma-generated waveforms, by simply connecting the instrument to the 50 Ohm input of the matching network of the plasma tool [1].

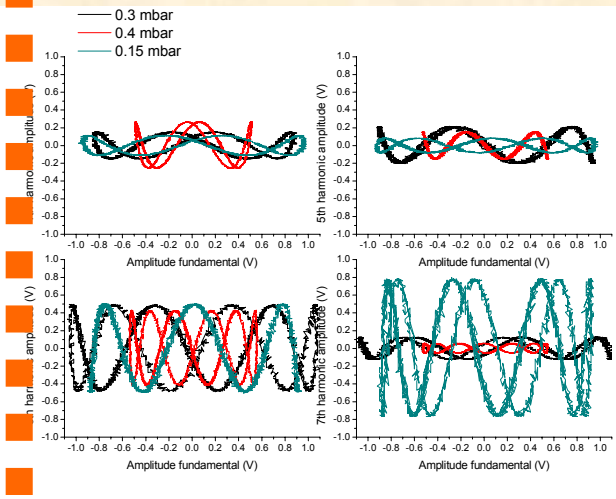


Diplexer provides -30 dB isolation between the harmonic channel and the fundamental
Harmonic Filters (n=2 to n=9) 1 MHz BW @-3 dB
Amplifier adjustable gain up to 35 dB



Noise figure =1.7

Spikes on the 7th channel reveal that the plasma-tool has poor electromagnetic immunity to the FM radio broadcast band

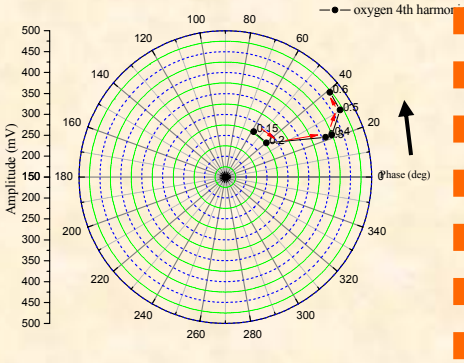


Lissajous figures

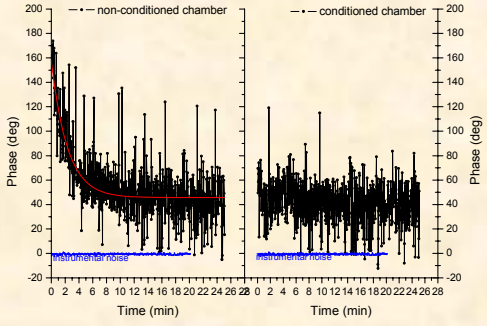
Lissajous figures are obtained by plotting one harmonic versus the fundamental. It is possible to extract information about the amplitudes and relative phase of the two waves by analysing the Lissajous features [2].

The changes in phase and amplitude reflect a variation in the plasma impedance, which is shown to be very sensitive to changes of plasma parameters like pressure and power.

Phase and amplitude measurements can be used to identify a **unique** plasma state as an **evolving 2-dimensional vector**, which can be visualized in a polar plot



Real-time phase measurements



The evolution of the state of the plasma can be monitored real-time by displaying changes in phase and amplitude.

As an example (left) the chamber conditioning is monitored by measuring phase changes in time. This measurement technique is very sensitive to the state of the plasma, showing a distinct exponential variation of the phase during the outgassing process and a settling to steady-state for conditioned chamber.

Transient spikes in the phase up to 8 times larger than the background noise may reveal some important event occurring at the time-scale typical of the mean gas residence time.

Automated monitoring and controlling system

[1] V. J. Law, A. J. Kenyon, N. F. Thornhill, V. Srigengan, I. Batty. **Vacuum** 57(1), 351 (2000)
[2] V. J. Law, A. J. Kenyon, N. F. Thornhill, A. J. Seeds, I. Batty. **J. Phys. D** 34, 2726 (2001)

Contact e-mail: s.bergamini@ee.ucl.ac.uk. Published in TPP7 "Progress in Plasma Processing of Materials", Strasbourg, France, June 18-June 21, 2002. pp. 127-134 (Begell House Inc, New York. 2003).