6-1-1998

Automated BWO design using iterative learning control

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Optical Spectroscopy of Plasma in High Power Microwave Pulse Shortening Experiments Driven by a Microsecond Electron Beam*

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Spectroscopic measurements have been performed to characterize the undesired plasma in a multi-megawatt coaxial gyrotron and a rectangular-cross-section (RCS) gyrotron. These gyrotrons are driven by the Michigan Electron Long Beam Accelerator (MELBA) at parameters: V= -800 kV, I_{tube}=0.3 kA, and pulselengths of 0.5-1 μs. Pulse shortening typically limits the highest (~10 MW) microwave power pulselength to 100-200 ns. Potential explanations of pulse shortening are being investigated, particularly plasma production inside the cavity and at the e-beam collector. The source of this plasma is believed to be due to water vapor absorbed on surfaces which is ejected, dissociated, and ionized by electron beam impact. Plasma H-α line radiation has been characterized in both time-integrated and temporally-resolved measurements and correlated with microwave power and microwave cutoff. Measurements from a residual gas analyzer (RGA) will be used to support this interpretation. Experiments involving RF plasma cleaning of the coaxial cavity are planned.

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*Research supported by AFOSR-MURI program contracted through Texas Tech University and by Phillips Lab and Northrop Grumman Corp.
+ AASERT support from AFOSR
# DOE MFET Graduate Fellowship
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Automated BWO Design Using Iterative Learning Control

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In our earlier works we reported on experimental results showing how finite length variations in a high power backward wave oscillator (BWO) will result in sinusoidal variations in both frequency and power outputs. By manually shifting the slow wave structure with respect to the cutoff neck by one-quarter of a wavelength we were able to achieve maximum frequency agility (large bandwidth).

Automated control of the shifting, beam current, and cathode voltage will allow the device to perform specific tasks and will ultimately lead to a "Smart Tube." Such tasks may include the ability to maximize power of efficiency for a given frequency, or to achieve maximum frequency agility at a given constant power. Accomplishing these goals requires the development of a learning control system in conjunction with directed hardware.

In this paper, we report on various completed subsystems of such a smart tube. In particular, we report on the implementation and testing of a vacuum-compatible step motor assembly and the corresponding motor control, for shifting the slow wave structure. We also report on the design and implementation of a pressure control device for the nitrogen in the spark gap, in order to adjust the cathode voltage. We finally report on the design and simulation of an iterative learning controller which automatically adjusts the pressure and shifting in order to achieve frequency agility.

*This work is supported through a High Energy Microwave Devices Consortium funded by an AFOSR/DOD MURI grant and administered through Texas Tech University..