A.5 : Development of High Power Solid State RF Amplifier

Solid State Power Amplifier is an integral part of Radio Frequency (RF) system of particle accelerators. Solid state technology enjoys extreme modularity, use of simple devices, high redundancy, freedom from high voltage supply, easier maintenance, no warm up time and simple start-up procedures. A 1.5 kW solid state RF amplifier at 350 MHz (Fig.A.5.1) has been developed successfully at the RF Systems and Control Division, RRCAT, using inexpensive RF components. The indigenous expertise for the development of multiport high power RF combiners /dividers, which are critical components for getting high RF power from ensemble of low power units, has been developed successfully. High RF of power operation was achieved by combining output from eight numbers of 250 W RF power modules. This module is basic building block of the high power system and operates at RF power gain of 12 dB. 20W and 40W low power driver modules are developed. (Fig.A.5.2). Multiport power divider / combiner was developed indigenously using 1-5/8” rigid line for output port and N connector for input ports. The RF power conversion efficiency of each module is above 60 %. For all power modules, impedance matching network was designed using coaxial transmission line transformer and micro strip transmission line, for getting repeatable performance and sufficient bandwidth. A negative feed back in the output network has been provided to prevent oscillations at low frequency and to obtain stable performance. Complete system operates at 28V DC and is housed in a normal 32U Euro cabinet. TCP/IP interface has been incorporated to monitor the performance remotely.

Fig.A.5.1 : High power Solid state RF Amplifier with eight way power combiners/splitters

Fig.A.5.2: 20W, 40W and 250W RF power modules

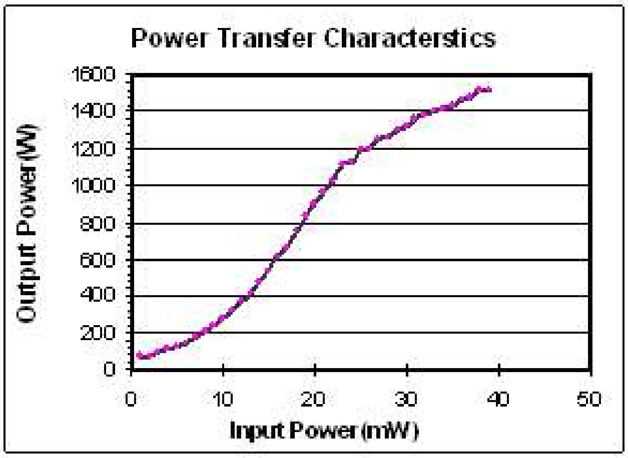

Fig. A.5.3 : Measured performance at 350 MHz

Various measurements (power transfer characteristics, effect of bias voltage etc.) of designed units have been done using high power directional coupler, RF dummy load, power meter and spectrum analyzer. Measured VSWR of this unit was 1.09 with power gain of 45 dB for complete chain. Measurements results for power transfer are shown in Fig.A.5.3.

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A.6 : Structural characterization of low-Z containing thin films using soft x-ray resonant reflectivity

Fine structure features of energy dependent atomic scattering factor near the atomic absorption edge is used for characterization of low-Z containing hard-condensed matter thin films. Near the atomic absorption edge, reflectivity provides increased sensitivity to particular interface of constituent elements due to tunable contrast of optical constants. This is illustrated through the characterization of boron carbide (B_4C) thin film and B_4C/iron bilayer deposited on float glass substrate.

Optical constants of B_4C undergo sharp variation with energy near boron K-edge (Fig.A.6.1). Near the edge, there is a sharp jump in ß (absorption index) while δ (refractive index decrement) dips to a negative value (anomalous effect). The measured optical constants of B_4C were obtained from best-fit results of soft x-ray reflectivity (XRR) measurements of 80 nm B_4C thin film. Far from the boron absorption edge (for 173 eV, 180 eV and 200eV), measured values of optical constants agree with Henke et. al. [B. L. Henke, E. M. Gullikson, and J. C. Davis, At. Data Nucl. Data Tables 54, 181, (1993)] within the experimental error of ~7 %. At the absorption edge, optical constants deviate significantly (~38%) from Henke et. al. At the absorption edge, these discrepancies in optical constants are due to uncertainty in the tabulated values.

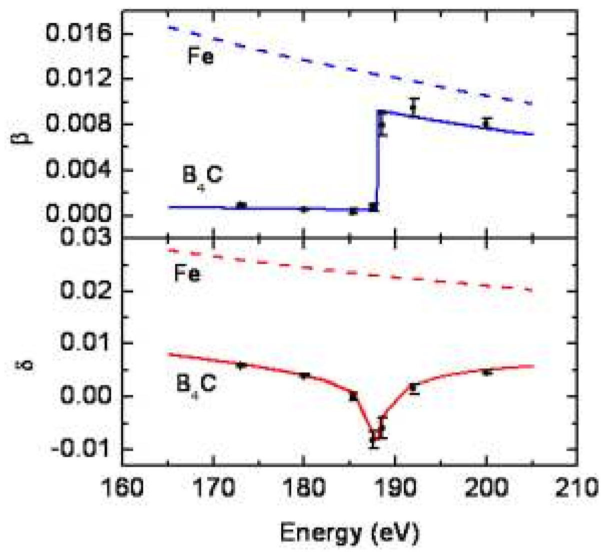

Fig.A.6.1 : Optical constants for B_4C and Fe versus photon energies near the boron K-absorption edge. Solid circles represent measured values of B_4C.

Results of soft XRR measurements carried out by Synchrotron Utilization and Materials Research Division (using Indus-1 reflectivity beamline) of B_4C-on-Fe bilayer film at selected photon energies are shown in Fig.A.6.2 along with fitted curve using Parratt's formalism *[L.G. Parratt, Phys. Rev. 95, 359 (1954)]*. At 180 eV, the amplitude of modulation is smaller compared to 173 eV and 187.5 eV, suggesting relatively lower sensitivity to B_4C/Fe interface. The high frequency oscillation gets modulated over the low frequency oscillation marked by vertical dotted line. The high frequency amplitude oscillation with $\Delta q_z^{B_4C} = 0.0096$ Å^{-1} corresponds to the thick B_4C layer, where as the low frequency amplitude oscillation with $\Delta q_z^{Fe} = 0.031$ Å^{-1} corresponds to the thin Fe layer. At 185.3 eV, the refraction index of B_4C is very close to refraction index of vacuum. This makes the B_4C layer almost invisible at this energy and low