Preliminary results of the Pt foil resistive bolometer on EAST

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1. Introduction

The EAST (Experimental Advanced Superconducting Tokamak) device is a full superconducting tokamak with the aim at long pulse operations and high performance plasma [1]. Presently, some diagnostics have been installed to provide the elementary plasma parameters including electron density, electron temperature, ion temperature, radiation power and so on [2]. The total radiated power as well as the radiation profile are measured by bolometer diagnostic. Two types of bolometer detectors known as metal foil resistive bolometer[3] and absolute extreme ultraviolet（AXUV） photodiodes[4] are utilized in plasma radiation diagnostic on EAST. Two AXUV photodiode arrays installed in horizontal C port, each with 16 channels covering half poloidal cross-section, have worked normally because of its simple operation and low price. The resistive bolometer was installed in EAST for the first time in 2010. The metal foil resistive bolometer are selected as the main bolometer detector due to the advantage of long-term stable and high absorption coefficients in wide spectrum (>90% above 30eV). In this article, the resistive bolometer system on EAST is described in section II and preliminary results are reported in section III. Finally, a brief summary is given.

2. Resistive bolometer system

The resistive bolometer installed in EAST are new type of radiation hard sensors based on the platinum (Pt) absorber deposited on silicon nitride (Si_3N_4) membranes developed by IPT GmbH [5].The traditional resistive bolometer usually use a gold absorber on thin kapton or mica foils with gold meanders on their back side. But they are not stable enough in high neutron flux due to transmutation of Au to Hg and the embrittlement of the kapton or mica foils. Besides more hard, the SiN based Pt detector can withstand higher temperature and have shorter response time compared with Au foil detectors. The sensors used on EAST have the same structure and dimension as their traditional gold foil sensors in order to match the same hardware. Four units are integrated to one bolometer head with dimension of 20 mm×33 m×15 mm. The area of each Pt absorber is 1.5 mm×4 mm with a thickness of 4 μm. The resistance of each meander is about 1.2 kΩ. The thickness of the silicon nitride foil is 1.5μm.

The metal resistor bolometer system is installed in the midplane of the horizontal E port. This horizontal array consists of 3 cameras with a total of 48 channels, as shown in Fig.1. The middle camera with 8 units total 32 channels view main plasma through an aperture of 3 mm (poloidal)×10 mm (toroidal). The two edge cameras, each with 8 channels, view the upper and lower divertor region separately through an aperture of 3 mm×13 mm. All the sensors in one camera are mounted on an arc holder and arranged equidistantly to the aperture center. The geometrical arrangement determined a spatial resolution δr of about 3~4cm .In last experimental campaign on EAST, only 20 channels of metal resistive bolometer for half poloidal cross-section are employed for the first time. The sensor supporting box is fixed on the inner wall of the diagnostic E port, as shown in Fig.2. The front part of the box facing plasma is covered by an additional molybdenum plate to shield neutron flux or runaway electron flux. The back board is made of copper convolved with water-carrying piping for active cooling. The cooling system is designed to protect the sensors during 250℃ backing and to minimize temperature drift in long pulse operation. Three thermocouples are embedded into the shielding box to monitor the temperature near the sensor heads. It is displayed that the bolometer heads are maintained below 35℃ during plasma operation and below 60℃ during baking.

The sensors are connected to amplifiers through low noise in-vessel cables, feedthrough and out-vessel cables. The analogue output voltage signals from amplifiers are sent to the special data acquisition (DAQ) system. The amplifiers and the DAQ PC are placed on the diagnostic platform near the torus (<10 m).The whole system is isolated with the torus and the flange are regarded as the floating ground. The sensor factors S (sensitivity) *and* τ_c (cooling time) are measured by an *in situ* calibration unit[3]. The average value of S *and* τ_c in vacuum are respectively 36.5 V/W and 173 ms.

3. Experiment Results

During the experiment, the resistive bolometer can work well. Fig.3 shows the typical output voltage of the resistive bolometer for EAST shot #29317. Two detector units, CH1 and CH6, are found damaged after installation. The brightness deduced from resistive bolometer is compared with that got from AXUV photodiode array, as shown in Fig.4. The discharge #29317 is ohmic circular plasma after wall conditioning of lithium coating. It is found that the signals can correspond basically. The values of resistive bolometer are slightly higher than AXUV photodiode results for peripheral chords mainly due to the sensitivity variation of AXUV photodiode in low photon energy while an average sensitivity value is used for data calculation. Because the sensors used on EAST adopt new materials being different from the traditional products, there are still problems to be resolved. Sometimes, the output voltage of amplifiers can not return to its back ground level after the discharge is over, such as the CH13 signal in Fig.3. This phenomenon becomes more serious for long pulse discharge more than 100s on EAST experiments. It is difficult to understand since the active water cooling system has insured low temperature near the sensors. In addition, the background noises for weak signals are higher than expected value. During the RF heating experiments, the signals have been affected by injected ICRH (ion cyclotron resonance heating) microwave with higher sharp noise, but no influences from LHW (low hybrid wave) are found. Further testing by manufacturer finds there exist slight coupling effect between channels on one sensor. Optimization will be done for these sensors to enhance their stability and signal to noise ratio. Modified sensors will be used in next experiment campaign.

3. Summary

The Si material based Pt foil resistive bolometer is installed in EAST for the first time in 2010. The system can work well. However signals receive influence from injected ICRF wave. The microwave shielding for sensor heads and the electronics will be improved. One mechanically controlled shutter has been designed and will be added in front of the aperture to protector the sensors during wall conditioning. Modified sensors are expected for better results in next experiment campaign.

Acknowledgements

It is a pleasure to acknowledge the assistance of EAST team to this work. This work supported partly by Chinese Nature Science Funds under Grant No.10935004 and National Magnetic Confinement Fusion Science Program under Grant Nos. 2008GB109003, 2010GB106000 & 2010GB106004.

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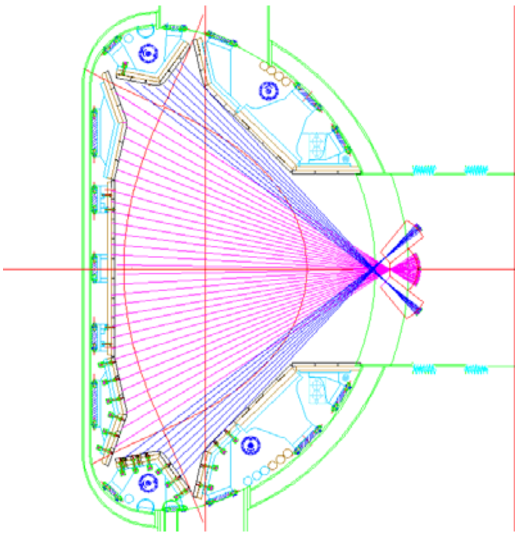

Fig.1 Viewing chords geometry of resistive bolometer diagnostics installed on EAST

Fig.2 Photograph of resistive bolometer after being installed in diagnostic E port

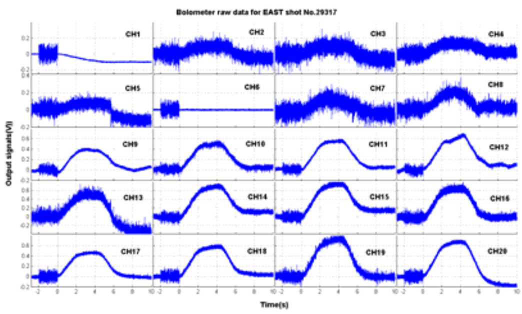

Fig.3 The typical output voltage signals of resistive bolometer on EAST

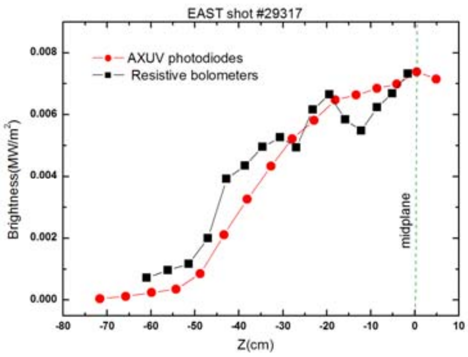

Fig.4 Comparison of brightness distribution deduced from and resistive bolometers and AXUV photodiodes for EAST shot #29317 at 3s.