Beam Monitoring on Graphite Targets by Infrared Thermography

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The thermal print of an ion beam on a target is related to the power density deposited in the target [1]. Infrared (IR) radiometry is one of the few methods suitable for the monitoring of high-intensity primary beams on production targets at FAIR. This work summarizes first results on online infrared imaging of beamspot size on thin graphite targets in experiments with ion beams at MeV-GeV energies using a FLIR SC 7500 high sensitivity, cooled IR camera. Due to their good thermo-mechanical properties and high emissivity, graphite targets are ideal for thermography-based beam diagnostic.

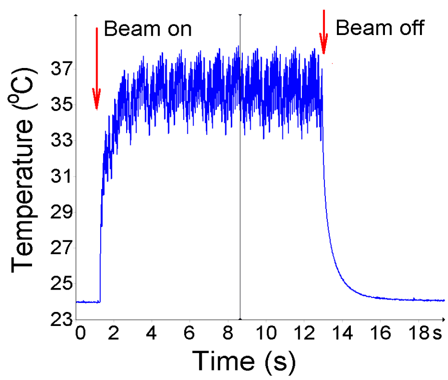

Figure 1: Temporal evolution of temperature within the center of the beam spot during irradiation with 1×10^9 i/cm^{2}s ^{197}Au ions with a energy of 3.6 MeV/u, 4 ms pulse length and a repetition rate of 38 Hz.

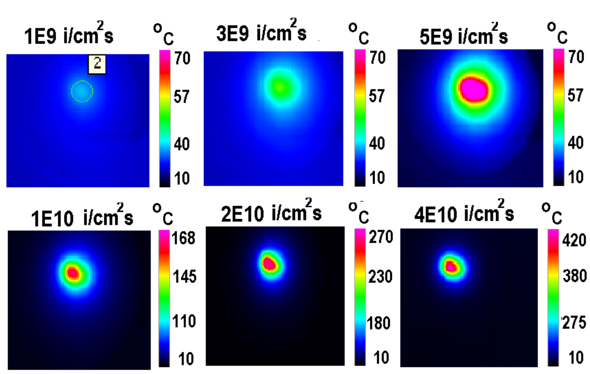

Figure 2: Sequence of infrared images of beam spot on thin graphite targets with increasing beam flux. Each image corresponds to maximum intensity during a pulse, for a 3.6 MeV/u, 4 ms, 38 Hz ^{197}Au beam.

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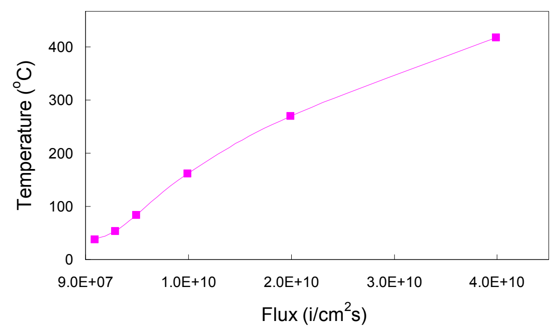

Figure 3: Maximum temperature recorded within the beamspot on thin graphite targets exposed to 3.6 MeV/u ^{197}Au ions, with increasing beam intensity, as a function of beam flux.

Figure 1 presents the time evolution of the temperature maximum within the beamspot of 3.6 MeV/u Au ions. The high sensitivity and low integration time of the camera provide a high accuracy monitoring of intensity variation during individual pulses. This type of information was used as input in finite element calculations of beam-induced thermal stress in targets. About 2 s are necessary for the temperature in the target to reach the steady state at the beginning of the irradiation, for the given beam parameters. Upon the beam stop, the time constant of the temperature decay in the target can be related to the thermal conductivity of the target materials.

To get accurate temperature distribution from the radiometric image of the ion heated target, previous calibration of the emissivity of the target and environment and of the transmittance of the beamline IR viewport are necessary. Figure 2 shows a series of thermal prints of Au ion beam pulses with increasing intensity on graphite targets. Snapshots are taken after the temperature in the targets reached a steady state condition (> 2 s) and at the maximum pulse intensity. The increase of the maximum temperature in the beamspot with increasing ion flux is shown in Figure 3. A detailed analysis of the fully radiometric image will be used for inferring the beam power density profiles providing the beam intensity profile. To validate these results, cross-checks using luminescence targets will also be done. This beam diagnostic technique is particularly suited for high intensity cases where other techniques would fail. Thermographic screens made out of carbon materials are also a cheaper alternative to luminescence screens.

[1] H. Buttig, "Beam Diagnostic by Infrared Thermography" ZKF-453 Report Forschungszentrum Rossendorf, Aug. 1981.