Synchrotron Radiation Testing of Surface Heating

The X-ray absorption length in copper for energies less than 50 keV is given roughly by

$$L_{abs}(\mu m) = \frac{1}{\mu\rho} = 7.6 \times 10^{-3} E^{2.85};\ E \text{ in keV}$$

where μ is the mass absorption coefficient and ρ is the density.* This gives 10 μm at E = 12.4 keV. These absorption depths are comparable to the heat diffusion depths for a high frequency acceleration structure. Could X-rays be used to simulate pulsed heating due to RF?

I have looked into this question for SSRL. Consider a bending magnet beam first at the normal operating energy of 3 GeV. The bending radius is ρ = 12.71 m. This gives a radiated power of $P_\gamma = 3.39\times10^{-7}$ W. The time for a 1 mrad bend is $\Delta t = \rho\Delta\theta/c = 4.24\times10^{-11}$ sec and an energy of $\Delta E = 1.44\times10^{-17}$ J per electron into 1 mrad. A typical SPEAR current is 50 mA; this gives a total power of 4.5 W/mrad. The SPEAR revolution period is 781 nsec an with roughly 20 bunches this gives an energy pulse of 1.8×10^{-7} J/mrad/bunch which is the pulsed power available. This estimate agrees with the numbers posted by SSRL on their WWW page

(http://www-ssrl.slac.stanford.edu/talk_display.html).

Look at the properties of Station 2-2 which is a 1 mrad white beam that has a spot size of 4.0 mm × 22 mm. The energy density per pulse is 2×10^{-3} J/m^2/bunch. This should be compared with pulsed energy densities of ~ 10^4 J/m^2 for 1 GeV/m and 0.1 μsec pulse lengths. The pulsed power density available at an SSRL bending magnet beam line is 7 orders of magnitude below that.

There are insertion devices at SSRL that have substantially higher powers. For example, station 10-2 has a white beam available that has ~300 times the power of station 2-2 in a 2.0 mm × 20 mm spot. This is a factor of 650 in energy density. This is still four orders of magnitude low in pulsed power density.

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* AIP Handbook of Physics, chapter 8.