Does localized cell heating due to absorption of laser radiation in optical tweezers occur, and if, can the extent be quantified?

Several works on this topic indicate, that there occurs only a slight increase in temperature if a proper wavelength is chosen. A good, and also very common and well tested wavelength is 1064 nm (see the mentioned article below). Another wavelength, where there is only a small increase of temperature with increasing laser power is around 800 nm. This is due to the fact, that there is a relative minimum of water absorption and of chromophore absorption. The main contribution of heating is due to the absorption of water.

Cell heating due to absorption: **≈ 1 – 1,5 °C per 100 mW applied laser power**
(for proper wavelength, depending on the type of cell)

A quite good work which is dealing with this topic is

Evidence of localized cell heating induced by infrared optical tweezers:

Y. Liu, D. K. Cheng, G. J. Soneck, M. W. Berns, C. F. Chapman and B. J. Tromberg
Biophysical Journal, 68, 1995, 2137-2144

Principle:

The measurements were done using a microfluorometric technique, making it possible to measure temperatures with micron spatial resolution. The measurement is based on optical measurement of temperature-dependent fluorescence spectra from dye-labelled bilayers in liposomes.
For detailed description and properties of the used dye, and the way how the measurement was performed see the mentioned paper.

Calibration of laser trapping power reaching the trapped sample:

To measure and calibrate the amount of power which is actually reaching the trapped particle, first the transmittance of the microscope objective was determined using the dual objective transmittance measurement technique of Misawa et al. . Using this method, all conditions are exactly the same as during the real experiment (measurements were done using immersion oil, coverslip and a water layer). During this measurement the power of the laser at the entrance of the microscope objective was monitored, so using this power value in combination with determined calibration factor, the actual power during the real experiment could be determined quite easy and with high accuracy.

Results: for a Zeiss PlanNeofluar 100x, 1,3 and λ=1064nm: T = 0,60 ± 0,05 *(consistent with reported value of 0,59 obtained for the same objective lens from Svoboda and Block)*

Determining the spot size:

This was done using the scanning knife edge technique of Firester et al. The spot size was determined from the 10% and 90% points of the beam intensity.

Results: for a Zeiss PlanNeofluar 100x, 1,3 and λ=1064nm: $D \approx 0{,}8 \pm 0{,}15 \mu m$

Results and discussion:

used particles:
spherical liposome vesicles with bilayer membranes composed of phospholipid 1,2-diacyl-pentadecanoyl-glycero-phosphocholine (15-OPC) : micron sized

and

Chinese hamster ovary cells

There occurs a heating of approximately 1,5°C per 100mW applied laser power (exact value for the 2 different kinds of particles see paper). The heating is governed by the absorption of water, rather than that of specific membrane or cell nucleus chromophores. This is a result of the fact, that the theoretically determined results, which do only take into account the absorption of water, are in very good agreement with experiment.

Depending on the type of cell under investigation, the increase of temperature may affect the physiological state of the trapped cell. Especially for motile cells, where trapping powers of a few 100 mW or more can be necessary, the temperature increase of several °C may be sufficient (e. g. sperm cell trapping). In case of simple non-motile cell manipulation at low laser power, the results indicate, that there no direct thermal damage may occur.

Further reference to this topic:

A microfluorometric technique for the determination of localized cell heating
Y. Liu, D. K. Cheng, G. J. Sonek, M. W. Berns, B. J. Tromberg
Appl. Phys. Lett. 65, 1994, 919-921,