we can estimate that the temperature can rise by several degrees around the nanoparticle. It is important to note that this measurement method results in very localized measurement of the temperature, on a scale of several tens of nanometers. Cells can survive brief exposure to localized plasma formation or complete ablation of sub-micron sized areas in the cytosol [25], and the nanoscale localized temperature increase is unlikely to manifest as an observable effect in the irradiated cell. Nevertheless it is necessary to understand if significant heating is occurring near the nanoparticle since this may affect protein folding, molecular binding, pH, or a number of other factors which may be of interest in the measurement.

7. Conclusion

In this work, we have successfully observed the behavior of nanoscale localized heating of a laser irradiated single gold nanoparticle by white light scattering spectroscopy. The temperature increment of approximately 10 degrees c was observed by irradiating a gold nanoparticle by 532 nm laser at ~1 mW. On the other hand, single gold nanopaticles irradiated by 488 nm did not display a measurable temperature rise, which is consistent with the notion that the heating is dominated by absorption of the incoming light at the surface plasmon resonance wavelength. Even laser irradiation of 0.01 mW or less appeared to produce a temperature dependent shift in the scattering spectra peak wavelength. This has implications for the use of nanoparticles in cellular environments and shows that the heating effect of laser light on nanoparticles may not be negligible, and should be further studied, particularly at wavelengths longer than 532 nm. It was also found that the local heating effects for each nanoparticle were not uniform and fluctuations were observed in both on-resonant and off-resonant cases. This indicates that the localized heating itself may be unstable and susceptible to the immediate environment. The effects of nanoscale heat conduction and convection flows over the particle may be responsible for some of the observed instability. Such high sensitivity temperature measurement for a nanoparticle at room temperature range together with nanometer spatial resolution has not previously been achieved. The method will be useful to estimate the local temperature effects of laser irradiated nanoparticles in a variety of materials including particles in an inorganic matrix and endocytosed or injected nanoparticles in living cells.

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