Thermal radiation measurements of Silicon microspheres

Salim Benadouda i Ivars

Directors
Ramon Alcubilla and Mosés Garin
ESCOLA TÈCNICA SUPERIOR D’ENGINYERIA DE TELECOMunicació DE BARCELONA

The Mie solution to Maxwell’s equations describes the interaction of a light wave with a sphere, in our case, of a few micrometers (IR region). The sphere has dimensions comparable to light wavelength; therefore it emits all radiation absorbed, making it the perfect emitter. The very well known Plank’s law describes the spectral radiance of EM radiation emitted by a Black Body at a given temperature.

\[ \phi_0(\lambda, T) = \frac{2\pi a^2}{\lambda^4} \frac{1}{e^{\frac{h\nu}{kT}} - 1} \]

From Mie’s theory, we can get that the absorption cross section of the microspheres is

\[ \sigma_a = \frac{2\pi a^2}{\lambda^4} \sum_{n=0}^{\infty} \left( \frac{\lambda}{a} \right)^{2n+1} \left( 1 - e^{-\alpha a} \right) \left( 1 - e^{-\beta a} \right) \]

where \( \alpha \) and \( \beta \) are the Mie coefficients that depend on wavelength and refractive indices of both the surrounding medium and the sphere.

Characterisation Techniques We used an FT-IR spectrophotometer combined with Lock-in techniques. Lock-in amplifiers are used in order to find oscillating small signals buried in noise. They use a technique known as phase-sensitive detection. It is based in orthogonality of sinusoidal functions. The lock-in multiplies the input signal by a sinusoidal function at a reference frequency. As all signals can be expressed by a sum of sinusoidal functions, the lock-in integrates the multiplication and only the term at reference frequency of the input signal survives.

\[ I_{lock}(\omega) = \frac{1}{2} \int I_{in}(\omega) \sin(2\pi f_{ref} + \phi) \sin(\omega) d\omega \]

In order to extract real spectrum from raw data, we should remove contributions from background radiation and from the instrument response function. To determine these functions we need to measure Black Body at different temperatures. The final emissivity is:

\[ e(\lambda) = \frac{R(\lambda) - I_{lock}(\lambda, T_{max})}{I_{BB}(\lambda, T_{max}) - I_{BB}(\lambda, T_{min})} \]

Experimental set-up and some results In order to check the set-up, a Black Body was measured at different temperatures.

Theoretical Black body radiation and experimental data gathered

Relative error of the experimental data