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Kamran, Faisal; Andersen, Peter E.; Jørgensen, Thomas Martini

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DTU Fotonik
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Non-contact assessment of the food quality using optical imaging methods

Faisal Kamran

Advisors: Peter E. Andersen and Thomas Martini Jørgensen

DTU Fotonik – Department of Photonics Engineering,

Technical University of Denmark, Frederiksborgvej 399, 4000 Roskilde, Denmark

Motivation : for the project rise from many folds of reasons. The ability to measure the quality of the food products is a key parameter for the food industry for many reasons. Firstly they need to sort out the raw material needed for the products, secondly it is important to maintain a uniform high quality product with minimum waste and thirdly, the most important requirement is, development and production of food products with required chemical, physical, sensory or health related properties. Accurate and efficient testing is essential for ensuring the quality and safety of the food we eat, and optical imaging methods have potential to provide the solution.

Challenge : is to relate relevant food quality characteristics to optical properties of food material. Central hypothesis is that a relation can be established between the wavelength dependent laser light scattering (optical properties), resulting from size and density distribution of scatterers, and the chemical and physical properties such as concentration and rheology parameters.

Take Home Message : This PhD thesis is part of the CIFQ[2] project and will contribute with model based approach towards establishment of a link between optical properties and physical parameters, which will improve the new data driven design methodology, by refining the research, resulting in a series of in-line and in process active illumination and computer vision based measurement systems for food quality analysis.

Transport regime:

1: Single scatterer.
2: No or reduced absorption.
3: No multiple scattering effects.
4: μ_s and g calculation

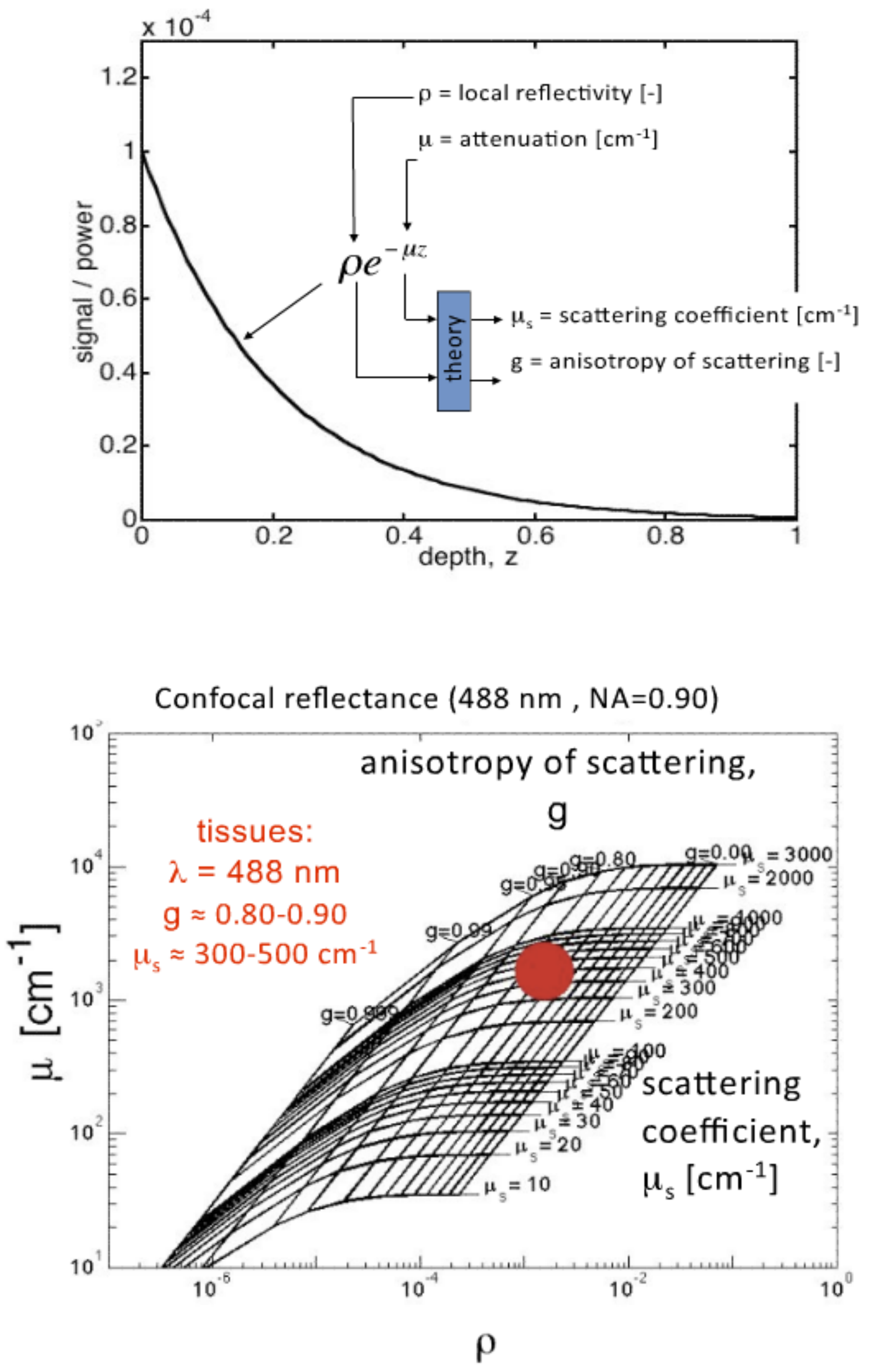

Fig 1: (Top)The reflectance signal decay shown as a function of depth of scanning following R(z)=ρ exp(−μz). (Bottom) Grid showing mapping of ρ and μ in to μ_s and g for excised murine skin samples.[1]

Methods of investigation include :

1) Confocal Microscopy (rCSLM)
2) Optical Coherence Tomography (OCT)
3) Optical Coherence Microscopy (OCM)

Transport reduced / diffused regime:

1: Multiple scattering effects.
2: Absorption.
3: μ_a and $\mu_s' = \mu_s(1-g)$ calculations.
4: Separate testing for μ_s and g.

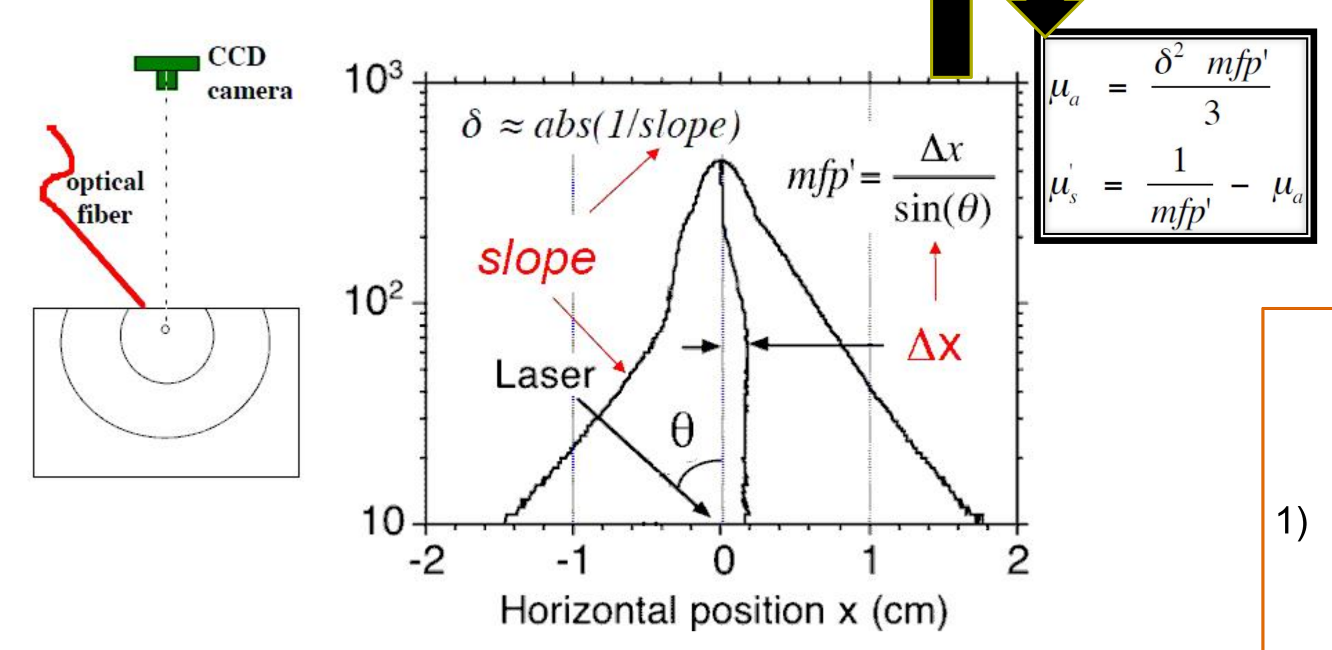

Fig 2: Oblique incidence Reflectometry showing center shift of diffuse reflectance profile and calculations of μa and μ_s' [3]

Methods of investigation include :

1) Normal incidence Reflectometry.
2) Oblique incidence Reflectometry.
3) Collimated Transmission
4) Integrating Sphere method

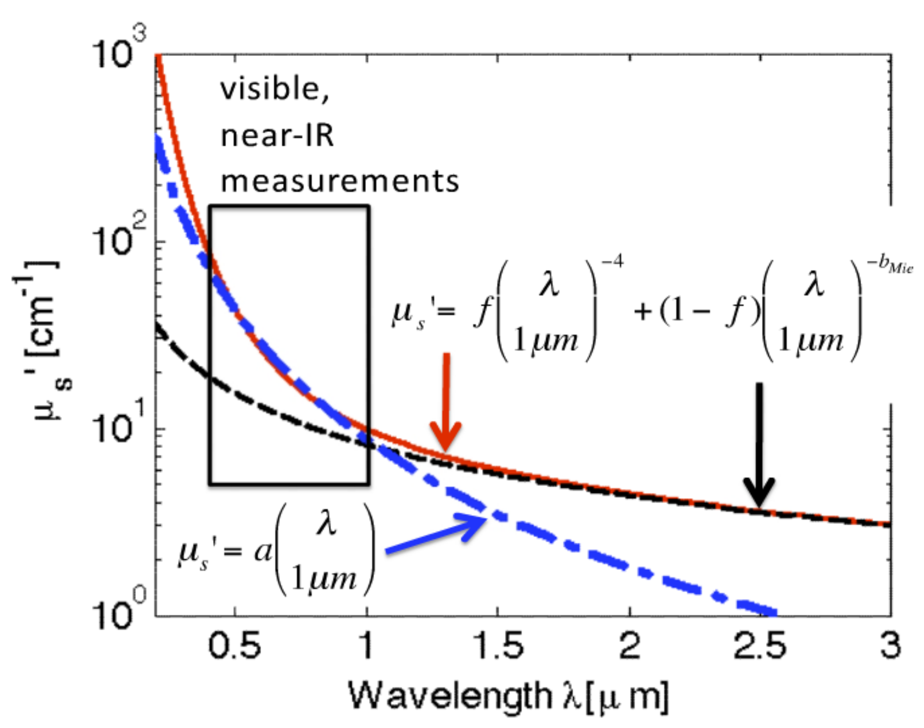

Fig 3: Wavelength dependent behavior of μ_s' in accordance with Mie Theory of light scattering .[4]

Comments: Various techniques are available for measuring different optical properties. Depending upon the physical parameters of the sample, appropriate method can be selected to determin the relevent optical properties. Measuring μ_s and g is more difficult but if the effect of physical changes in the sample can be investigated clearly by these properties, method that can operate in transport regime will be more appropriate for measurements. For exmple food or skin samples can be investigated for changes in μ_s & g, using rCLSM non-invasively,. Measuring μ_s or g , however, using diffused reflectometry will require the sample to be investigated invasively using collimated transmission or integrating sphere method. Hence, the choice of method is dependent on sample under investigation and whether the process needs to be non-invasive.

References:

[1] R. Samatham, S. L. Jacques, and P. Campagnola, "Optical properties of mutant versus wild-type mouse skin measured by reflectance-mode confocal scanning laser microscopy (rCSLM)," J. Biomed. Opt. 13, 041309 (2008).

[2] http://www.cifq.dk/

[3] **Link to lectures at Biophotonics '09** http://www.biop.dk/biophotonics09/after/After.asp

[4] http://www.biophotonicsworld.org/events/167-bp-l-webinar-optical-scattering-as-a-contrast-mechanism-toward-label-free-imaging-of-cancer