Soot Light Absorption and Its Optical Band Gap

Swiss Federal Institute of Technology Zürich

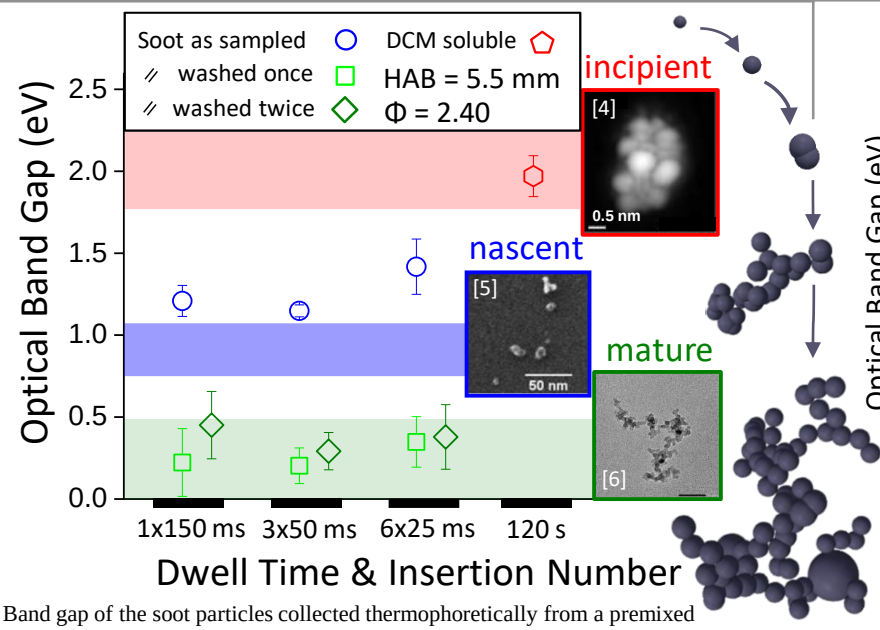

R. Floeder, M. R. Kholghy, and S.E. Pratsinis
Particle Technology Laboratory, ETH Zürich, CH-8092 Zürich, Switzerland
mkholghy@ethz.ch

PTL
www.ptl.ethz.ch

Motivation

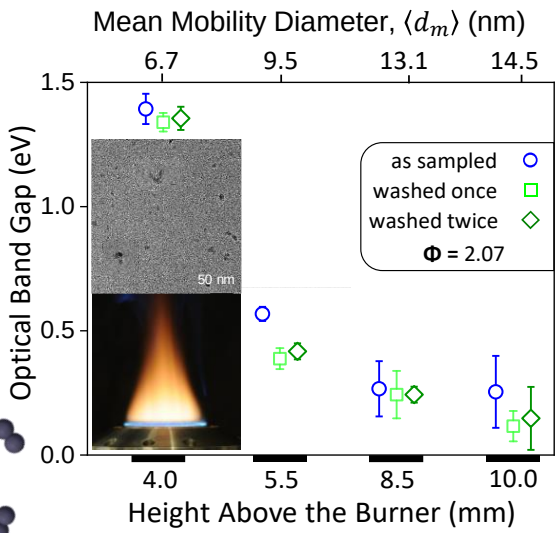
Soot particles contribute to global warming by their strong light absorption. However, assessments of the impact of soot on climate change are hindered by the large uncertainty of their optical properties. Soot optical band gap can be used to accurately quantify the evolving refractive index of soot and correlate it to soot maturity [1]. Here, the optical band gap of soot is measured for two premixed flames with different equivalence ratios. It is shown that volatile organic carbon (VOC) significantly changes the soot light absorption and optical bandgap. Once VOC is removed, the measured band gap of the large soot particles compares well with values reported for mature soot [2]. For small particles, the measured bandgap correlates well with the values suggested by the quantum confinement theory, indicating that soot optical bandgap monotonically decreases with increasing mobility size [3].

Band Gap of Incipient, Nascent and Mature Soot



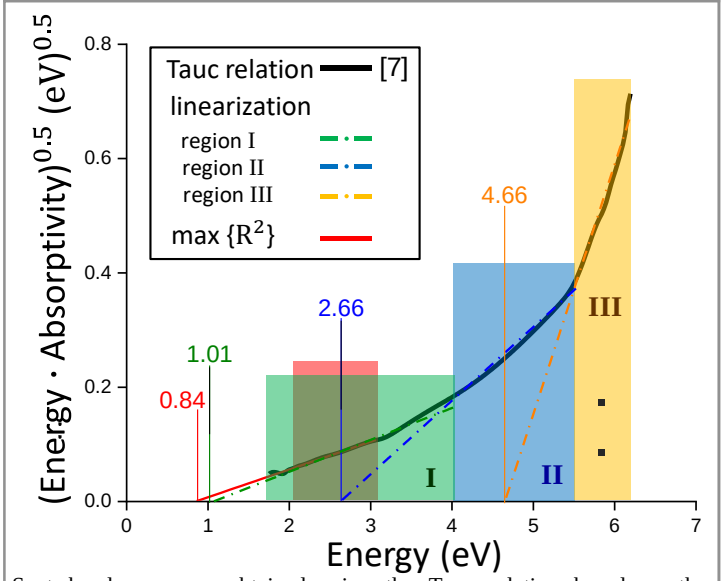
Band gap of the soot particles collected thermophoretically from a premixed flame and measured as sampled and treated with dicholoromethane (DCM) solvent to remove the volatile organic carbon (VOC) from the particles.

Evolving Soot Band Gap in a Flame



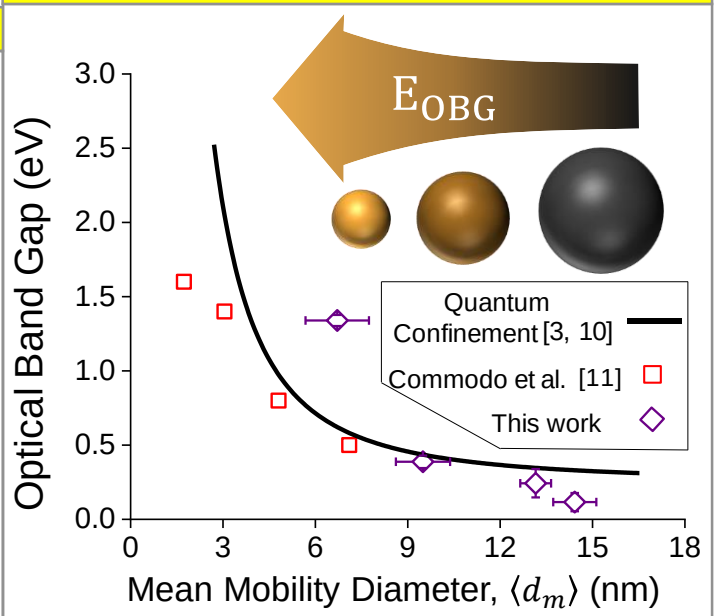
Soot optical band gap decreases monotonically from 1.4 to 0.2 ev, by increasing soot mobility diameter and maturity as particles grow in the flame.

Obtaining Soot Band Gap from Absorptivity



Soot band gaps are obtained using the Tauc relation based on the multiwavelength absortivity curves. Observing linear regions with different slopes suggests mixing of particles with different bad gaps [8].

Optical Band Gap and Quantum Confinement



The measured soot optical band gaps agree well with the values calculated with the quantum confinement theory [3] suggesting that particle size and maturity evolve together in the falmes.

References

[1] Kelesidis, G.A.; Pratsinis, S.E. P Combust Inst, .
[2] Russo, C., Apicella, B., Lighty, J.S., Ciajolo, A. and Tregrossi, A., 2017. *Carbon*, *124*, 372.
[3] Liu, C., Singh, A.V., Saggese, C., Tang, Q., Chen, D., Wan, K., Vinciguerra, M., Commodo, M., De Falco, G., Minutolo, P. and D'Anna, A., 2019. PANS In press.
[4] Schulz, F., Commodo, M., Kaiser, K., De Falco, G., Minutolo, P., Meyer, G., Andrea, D. and Gross, L., 2019. *P Combust Inst*, *37*, 885.
[5] Schenk, M.; Lieb, S.; Vieker, H.; Beyer, A.; Golzhauser, A.; Wang, H.; Kohse-Hoinghaus, K. ChemPhysChem 2013, 14, 3248.
[6] Kelesidis, G.A.; Kholghy, M.R.; Zurcher, J.; Robertz, J.; Allemann, M.; Duric, A.; Pratsinis, S.E. Powder Technol, in press.
[7] Tauc J, Grigorovici R, Vancu A. *Phys Status Solidi.* 1966;15:627.
[8] Minutolo P, Gambi G, D'Alessio A. P Combust Inst, 1996;951-957
[9] Abid AD, Heinz N, Tolmachoff ED, Phares DJ, Campbell CS, Wang H. *Combust Flame.* 2008;154:775.
[10] Singh A, Liu C, Wan K, Wang H. *10th US National Combustion Meeting:* 2017:1-6.
[11] Commodo M, De Falco G, Bruno A, et al. *Combust Flame.* 2015;162, :3854.

Funding

FNSNF
Fonds national suisse
Schweizerischer Nationalfonds
Fondo nazionale svizzero
Swiss National Science Foundation

This work was supported by the Swiss National Science Foundation (grant Nr. 182668 and 183298)

Conclusions

1. Soot optical band gap decreases with increasing soot maturity and size.
2. Volatile Organic Carbon condesed on the surface of soot pamples could significantly change its light absorption properties.