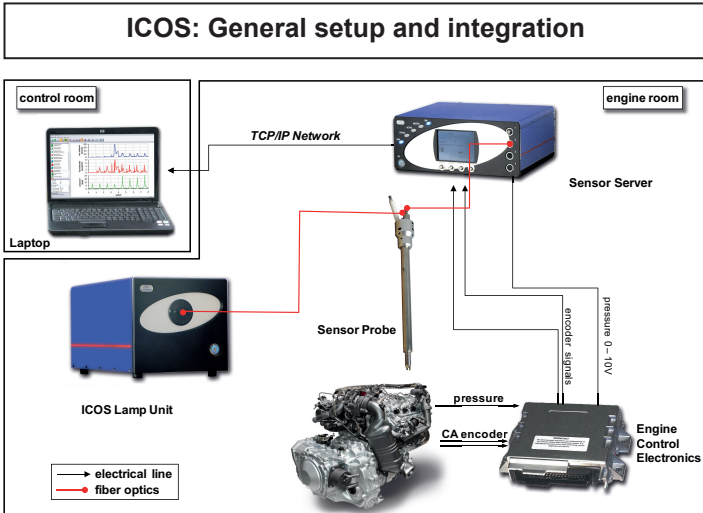


# Transient analysis of both lambda and EGR values measured locally with crank angle resolution in IC engines using a fiber optic sensor

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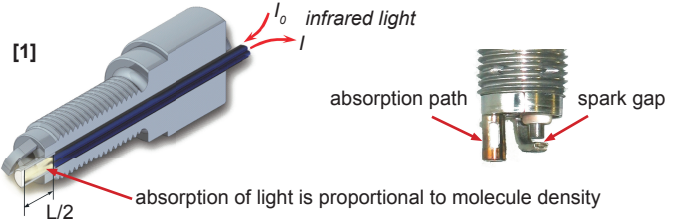
### Working principle of the IR probe

#### Measuring with light

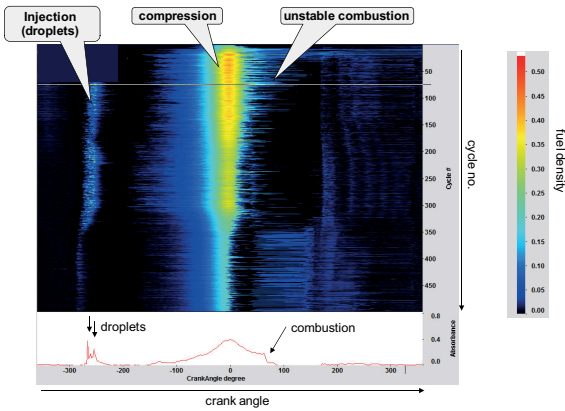
- ▶ gaseous molecules absorb light
- ▶ noninvasive, no gas extraction
- ▶ quick response time

#### Technical benefits

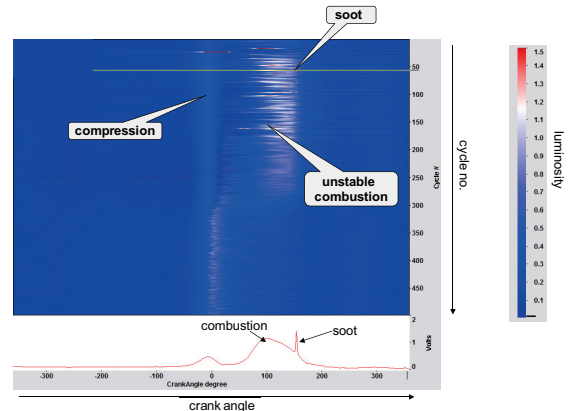
- ▶ crank angle resolved measurements
- ▶ fiber optical probes
- ▶ capability of spark plug integration



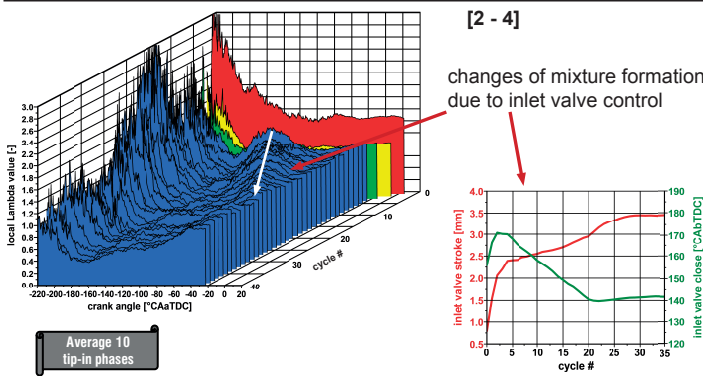
### Cold start: Transient - cycle resolved – fuel density traces plotted as false-color 2D intensity map



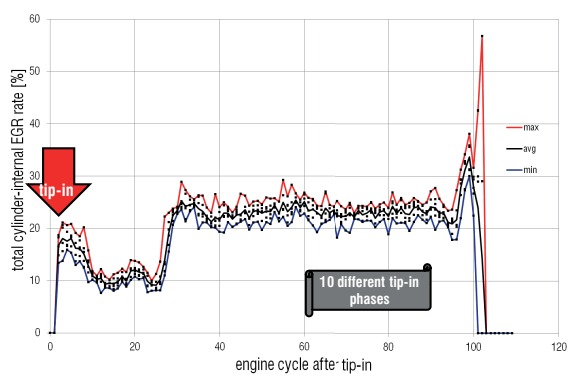
### False-color 2D map of background luminosity signals detected simultaneously with fuel density (left)



### Tip-In: Transient lambda detection for the analysis of mixture formation depending on valve timing



### In-Cylinder Exhaust Gas Recirculation Rate (EGR) after Tip-In



**References:**  
 [1] Berg, T., Thiele, O., Seefeldt, S., Vanhaelst, R., "Measurement of in-cylinder mixture formation by optical indication," MTZ worldwide, Vol. 74, 2013.  
 [2] Disch, C., Kubach, H., Pfeil, J., Koch, T., Spicher, U., Thiele, O., Donn, C., Schyr, C., "Cycle-resolved combustion diagnostics of a direct injection gasoline engine in transient operation," 11th International Symposium on Combustion Diagnostics, 2014, Baden-Baden.  
 [3] Disch, C., Pfeil, J., Kubach, H., Koch, T., Spicher, U., Thiele, "Experimentelle Untersuchungen zur Entwicklung des kurbelwinkel aufgelösten Brennraumluftverhältnisses im Transientbetrieb eines Ottomotors mit Direkteinspritzung", published in Ladungswechsel im Verbrennungsmotor, 7.MTZ-Fachtagung, 2014  
 [4] Disch, C., Pfeil, J., Kubach, H., Koch, T., Spicher, U., Thiele, "Experimental Investigations of a DISI Engine in Transient Operation with Regard to Particle and Gaseous Engine-out Emissions", JSAE 201509125, 2015.