Supporting Information

Electrothermal Metallic Furnace Atomic Absorption Spectrometry.

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Script used for temperature modelling with FlexPde

```
title "EMFAAS temperature distribution"

  select

nominmax = on
    { stages = 3
     errlim = staged(1e-3,1e-4,1e-5)
     autostage=off
}

 coordinates
xcylinder('Z','R')


  Variables
     Temp           { Identify "Temp" as the system variable }

  definitions
     K = 1                         { define the conductivity }
     source = 0                       { define the source }
     Tzero = 0                      { define the coolant temperature }
     flux = -K*grad(Temp)              { define the thermal flux vector }

  Initial values
     Temp = 0

  equations
     div(K*grad(Temp)) + source = 0   { define the heatflow equation }

  boundaries

BOUNDARIES


REGION 1 'air'

{MESH_DENSITY = 1}

k=0.19

START(-10,-0)

natural(Temp)=0               {adiabatic at center }
LINE TO (-10,0) TO (10,0)

value(Temp)=25                 {25 C air around}
LINE TO (10,10)
 line to (-10,10)
 line to close

 region 2 'pared del tubo'


{MESH_DENSITY = 10}

k=0.034
source=1200

start (-2.5,.5)
{NATURAL(Temp) = -k*Temp^4}


line to (2.5,.5) to (2.5,0.6) to (-2.5,0.6) to  close


region 10 'aleta izq'


{MESH_DENSITY = 10}

k=0.004
source=1000

start (-2.5,.6)
{NATURAL(Temp) = -k*Temp^4}


line to (-2.4,0.6) to (-2.4,1.9) to (-2.5,1.9) to  close
```

```
 region 11 'aleta der'

{MESH_DENSITY = 10}

k=0.004
source=1000

start (2.5,.6)
{NATURAL(Temp) = -k*Temp^4}

line to (2.4,0.6) to (2.4,1.9) to (2.5,1.9) to  close

  region 3 'cobre izq'
k=111

start (-2.5,1.5)

line to (-2.5,2) to (-3.0,2) to (-3.0,1.5) to close

   region 4 'cobre der'
k=111

start (2.5,1.5)

line to (2.5,2) to (3.0,2) to (3.0,1.5) to close

  region 5 'cooler izq'
k=100

start (-3.0,1.5)
value (Temp)=25
line to (-3,2) to (-3.5,2) to (-3.5,1.5) to close

 region 5 'cooler der'
k=100

start (3,1.5)
value (Temp)=25
line to (3,2) to (3.5,2) to (3.5,1.5) to close

  monitors
    contour(Temp)                { show contour plots of solution in progress }

  plots                          { write these hardcopy files at completion: }
    grid(z,R)                    { show the final grid }
    contour(Temp) painted                { show the solution  }

contour(Temp) zoom(-5,0,10,10) painted
 contour(Temp) zoom(-8,0,16,16) painted
ELEVATION(Temp) FROM (-2.5,0) to (2.5,0)
ELEVATION(Temp) FROM (-3.5,.55) to (3.5,.55)
ELEVATION(Temp) FROM (-8,.6) to (8,.6)

  end
```

Temperature imaging calibration

Consumer digital cameras employ several strategies to deal with the occurrence of dark and illuminated zones within the frame. A typical way to diminish over and under exposition is the use of a nonlinear light flux to pixel value scale. To calibrate this relationship in order to linearize the camera response to light a primary calibration was performed as follows:

A set of pictures of the EMFAAS cell, heated to 835 ^{o}C at the maximum, were taken at different exposure times between 1 and 1/30 seconds. The obtained images were stacked into *ImageJ* and a zone was chosen to perform the calibration as shown in Figure S1 for the G channel.

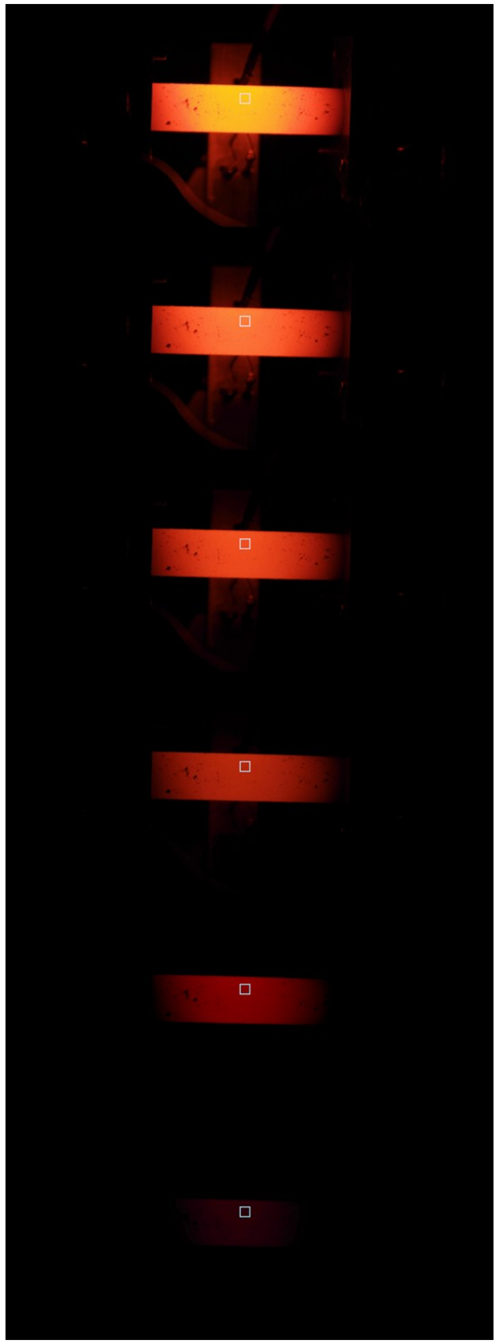

Figure S1. Images of the heated EMFAAS cell (T = 835 ºC) taken at 1, 1/2, 1/4, 1/10,1/15 and 1/30 seconds from top to bottom. The indicated square area was taken as a calibration point.

A similar calibration was done for the R channel at a zone of lower temperature to avoid image saturation. Since the goal of this calibration is merely to map the integrated light intensity (taken from the exposure times) to the pixel values, the exact temperature of the used zones are irrelevant, but pixel values near saturation (255) must be avoided. The results are depicted in Figure S2.

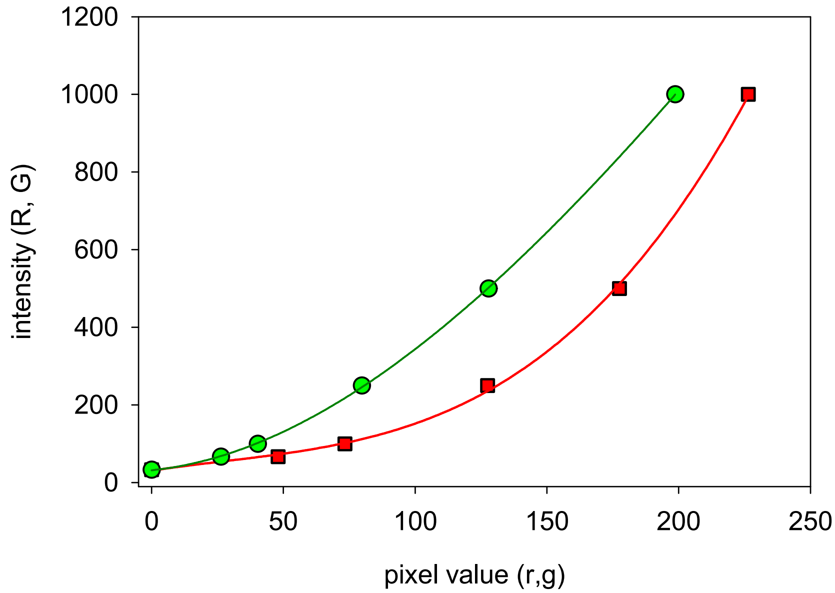

Figure S2. Relationship between pixel value and light intensity for the images of Fig. S1. Squares: Red channel. Circles: Green channel. The curves were fitted with cubic polynomials (see text).

The plots show a strong nonlinearity in both channels R and G. Cubic polynomials were chosen to fit the pixel values between 30 and 220 digital units. The results are the following:

$$R = 9.854\times10^{-5}\, r^3 - 8.021\times10^{-3}\, r^2 + 1.029\, r + 30.8 \qquad \text{Eq. s1}$$

$$G = -3.305\times10^{-5}\, g^3 + 2.762\times10^{-2}\, g^2 + 0.686\, g + 31.9 \qquad \text{Eq. s2}$$

Once obtained R and G values in arbitrary units (linearly related to exposure times), the Temperature vs. intensity calibration was done. Images of the heated EMFAAS cell from 724 ºC to 990 ºC were taken under the same conditions at adequate exposure times for imaging the very variable emission. The temperature was taken with a K thermocouple introduced into the cell through the injection hole. The temperature for calibration was taken from a 4 mm^2 zone directly in contact with the thermocouple. The results are shown in figure S3.

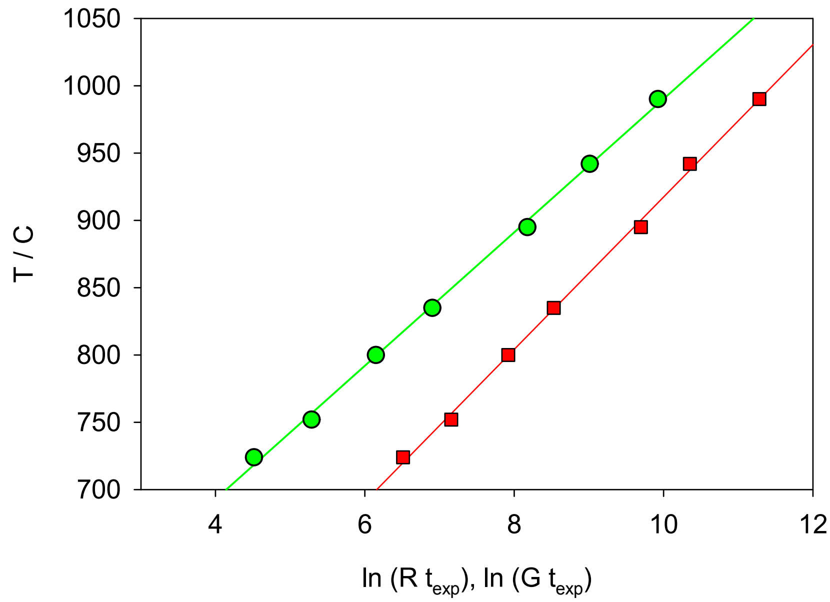

Figure S3. Relationship between R or G values and temperature. Squares: Red channel. Circles: Green channel.

The linear relationship between temperature and ln(R) or ln(G) was fitted with the following equations:

$T = 56.572 \ln(R / t_{exp}) + 351.64$ Eq. s3

$T = 49.554 \ln(G / t_{exp}) + 494.65$ Eq. s4

where R and G are the values obtained using Eq. s1 and Eq. s2 and t_{exp} the exposure time of the picture measured in seconds.

Once obtained the calibration curves, the complete procedure to obtain a temperature image is summarized as follows:

1) Take a picture at a exposure time that generates pixel values between 30 and 220.

2) Use equations s1 or s2 to obtain the R or G intensity values.

3) Multiply the light intensity by the reciprocal of the exposure time in seconds.

4) Use the respective s3 or s4 equations to obtain the temperature.

Note that different cameras even of the same model can have different calibration curves.

Table s1: Error analysis of T measurement at different exposure times and temperatures.

shutter	2	4	10	15	30
t_{exp} / s	0.500	0.250	0.100	0.067	0.033
T/C	Green channel raw pixel values (g)				
724	0.0	0.0	0.0	0.0	0.0
752	35.5	0.0	0.0	0.0	0.0
800	68.2	40.9	0.0	0.0	0.0
835	127.9	79.7	40.3	26.3	0.0
895	229.6	175.8	101.7	72.9	41.7
942	254.5	237.4	172.7	126.7	81.0
990	255.0	255.0	236.2	208.6	143.8
	G intensity values (obtained with Eq. s2)				
T/C					
724					
752	89.6				
800	196.8	103.9			
835	502.2	245.5	102.2	68.5	
895	1245.8	826.4	352.5	216.1	106.1
942			804.2	495.3	251.1
990				1077.0	603.2
T/C	Light intensity (G / t_{exp})				
724					
752	179.1				
800	393.7	415.6			
835	1004.4	982.0	1021.7	1027.2	
895	2491.7	3305.7	3524.6	3242.1	3181.9
942			8041.7	7428.8	7532.1
990				16154.6	18097.3
T/C	Temperature (obtained with Eq. s4)				
724					
752	751.7				
800	790.8	793.4			
835	837.2	836.1	838.0	838.3	
895	882.2	896.2	899.4	895.2	894.3
942			940.3	936.3	937.0
990				974.8	980.5
T/C	Temperature (% Kelvin relative error)				
724					
752	0.0%				
800	-0.9%	-0.6%			
835	0.2%	0.1%	0.3%	0.3%	
895	-1.1%	0.1%	0.4%	0.0%	-0.1%
942			-0.1%	-0.5%	-0.4%
990				-1.2%	-0.8%