Electronic Supplementary Material (ESI) for Analytical Methods.

Difluoroboron β-Diketonate Materials with Long-Lived Phosphorescence Enable Lifetime Based Oxygen Imaging with a Portable Cost Effective Camera

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Supporting Information

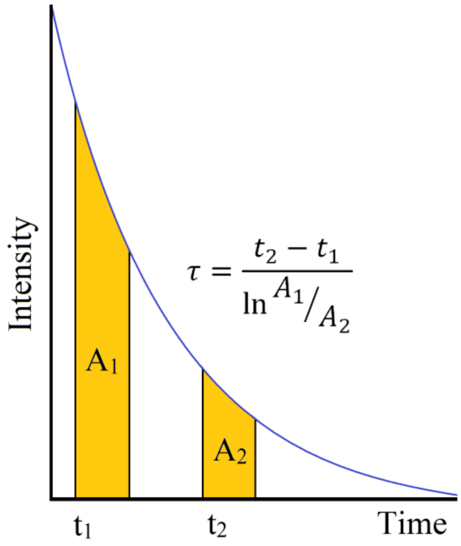

Figure S1. An illustration of how Rapid Lifetime Determination (RLD) is computed. The blue line shows a typical decay and the yellow shaded regions represent integrated regions, A_1 and A_2, bounded by times t_1 and t_2.

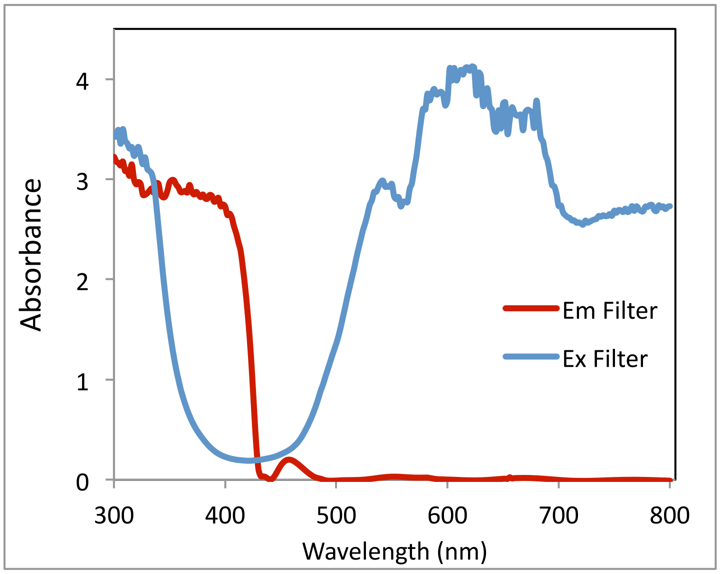

Figure S2. Absorbance spectra of emission and excitation filters.

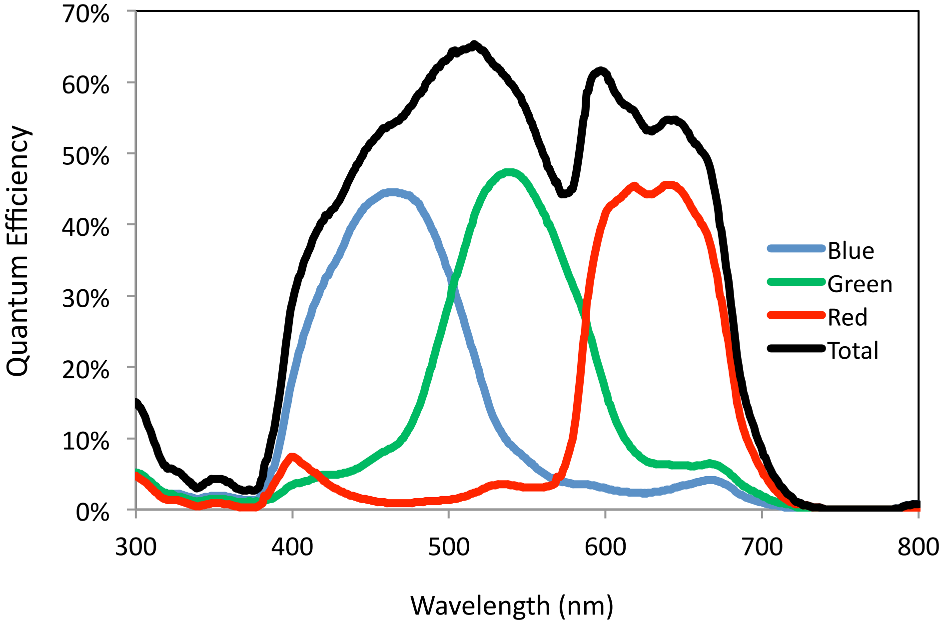

Figure S3. Quantum efficiency plot of all color channels of the PGR GS3-U3-41C6C-C camera. Total emission is determined by summing all three channel intensities. Adapted from http://www.ptgrey.com/.

Table S1. Rationale and Cost of Hardware Components.

Component	**Rationale**	**Cost**
PGR Grasshopper3 CMOS Camera	This camera is ideal for a simple, portable, and reliable imaging device. Performance specifications (2048x2048 max resolution, 2000 FPS at reduced resolution, ~50% quantum efficiency) were excellent at this price. Further the camera is small and can transmit data and power through a single USB 3.0 cable, maximizing simplicity.	$1200
Spacecom f/0.95 50 mm lens	Imaging at high framerates results in fewer photons reaching the camera sensor per frame. To compensate, this fast lens was chosen.	$800
Yongnou 560-II Flash Unit	This flash unit (normally used for photography) can reproduce very fast pulses compared to the lifetimes of our dyes. The brightness and frequency of these pulses is adjustable. The unit is inexpensive and portable and operates on battery power.	$60
Esco Optics 425 nm bandpass filter	This filter blocks most of the broad emission of the flash unit while passing a range of wavelengths sufficient to excite most of the boron dyes, thus reducing noise.	$100
Edmund Optics 425 nm long pass filter	This filter suppresses most of the excitation light while passing the emissions of most of the boron dyes.	$100
Lenovo w530 Laptop	A computer was needed to process and display data. A laptop was chosen for portability. The following components were necessary to accommodate the large data output of the camera: Intel Core i7-3940XM processor 32 GB RAM Intel 180 GB solid state drive NVIDIA Quadro K2000M graphics card USB 3.0 Ports	$2700
		Total: $4960

```
%Delete any pre-existing camera connections
delete(imaqfind)

% %Specify resolution
str={'RW08_160x120','RW08_320x240','RW08_640x480',...
    'RW08_800x600','RW08_1024x768','RW08_1280x960','RW08_1600x1200','RW08_2048x2048'};
sel = listdlg('PromptString','Select a resolution:','SelectionMode','single','ListString',str);

% %Gain control of camera and ensure correct parameters
vidobj = videoinput('winvideo',3,char(str(sel)));
src = getselectedsource(vidobj);
src.ExposureMode='manual';
src.GainMode='manual';
src.Brightness=0;
Exposurevals=propinfo(src,'Exposure');
src.Exposure=max(Exposurevals.ConstraintValue);
src.Gain=0;
src.Gamma=100;
vidobj.BayerSensorAlignment='gbrg';
vidobj.ReturnedColorSpace='bayer';
triggerconfig(vidobj, 'manual');
framerate=str2num(get(src,'FrameRate'));
start(vidobj);

%preallocate
maxLife=.213;
minLife=0;
vidRes = get(vidobj, 'VideoResolution');
imageRes = fliplr(vidRes);
mapframes=zeros(imageRes(1),imageRes(2),3,2);

%Create a image object for background acquisition
H=imshow(zeros(imageRes(1),imageRes(2),3));

%Create UI buttons to start and stop imaging
btnBR = uicontrol('Style', 'pushbutton', 'String', 'Take BR',...
    'Position', [100 350 100 50],...
    'Callback', 'H.AlphaData=2;');

btnStart = uicontrol('Style', 'pushbutton', 'String', 'Start',...
    'Position', [100 300 100 50],...
    'Callback', 'H.AlphaData=3;');

while true
switch H.AlphaData
    case 1
      %preview the stream to take a background image until Start
       set(H,'CData',getsnapshot(vidobj));
      drawnow
    case 2
      %store the background image
      br=getsnapshot(vidobj);
      H.AlphaData=1;
    case 3
      %close background panel and begin imaging
      close all
      break
end
end

%Create a scaled image object bounded by max and min lifetimes
J=imagesc(zeros(imageRes(1),imageRes(2)),[minLife,maxLife]);
```

```
map=colormap(jet(256));
btnStop = uicontrol('Style', 'pushbutton', 'String', 'Stop',...
    'Position', [100 330 50 20],...
    'Callback', 'J.AlphaData=2;');

%begin RLD imaging
 while true
   switch J.AlphaData
     case 1
  %Scan for excitation pulse
  if mean2(getsnapshot(vidobj))>150

  %capture 2 consecutive frames and subtract the background frame
  mapframes(:,:,:,1)=getsnapshot(vidobj)-br;
  mapframes(:,:,:,2)=getsnapshot(vidobj)-br;

  %perform RLD pixel-wise using the green channel
  frame=(1/framerate)./(log(mapframes(:,:,2,1)./mapframes(:,:,2,2)));

  %NOTE AN OXYGEN CALIBRATION FUNCTION IS APPLIED HERE GIVEN BY F
  %frame=F(frame);

  %Display and update
  set(J,'CData',frame);
  drawnow;
  end
     case 2
       break
   end
 end

stop(vidobj);
close all
```

Figure S4. RLD MATLAB Code

Sensor Linearity

Sensor linearity was determined by monitoring the output intensity of a uniformly illuminated white sheet of paper. The signal was recorded and then attenuated by applying combinations of photographic neutral density filters. Intensities were determined by averaging 8 bit values across the entire sensor for each of the color channels and summed over all channels for 20 frames.

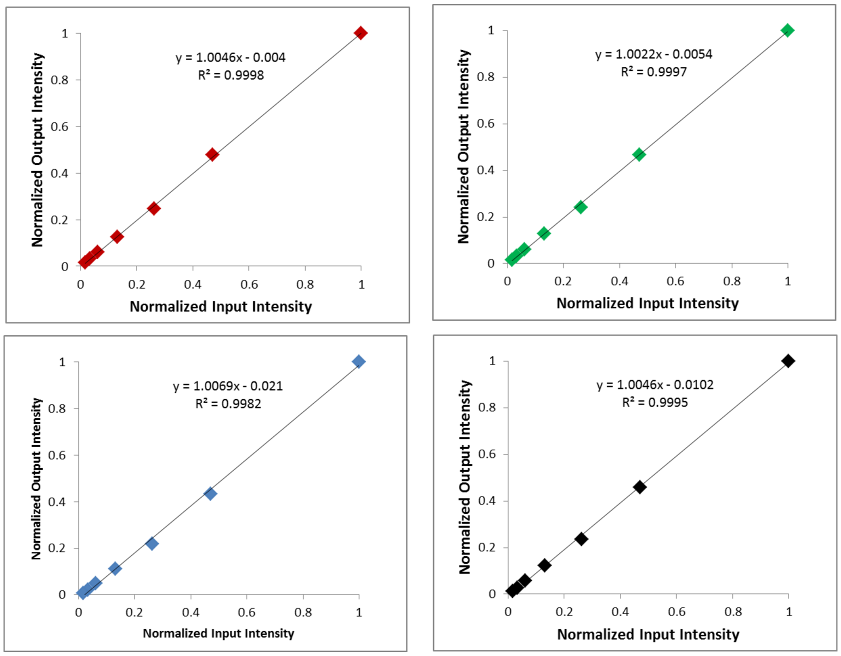

Figure S5. Linearity of red (top left), green (top right), and blue (bottom left) channels as well as total emission (bottom right).

Table S2. Optimal RLD Parameters for Selected Dyes.

Dye	t_1 (ms)	t_2 (ms)
1	99	154
2	44	110
3	66	132
4	44	110

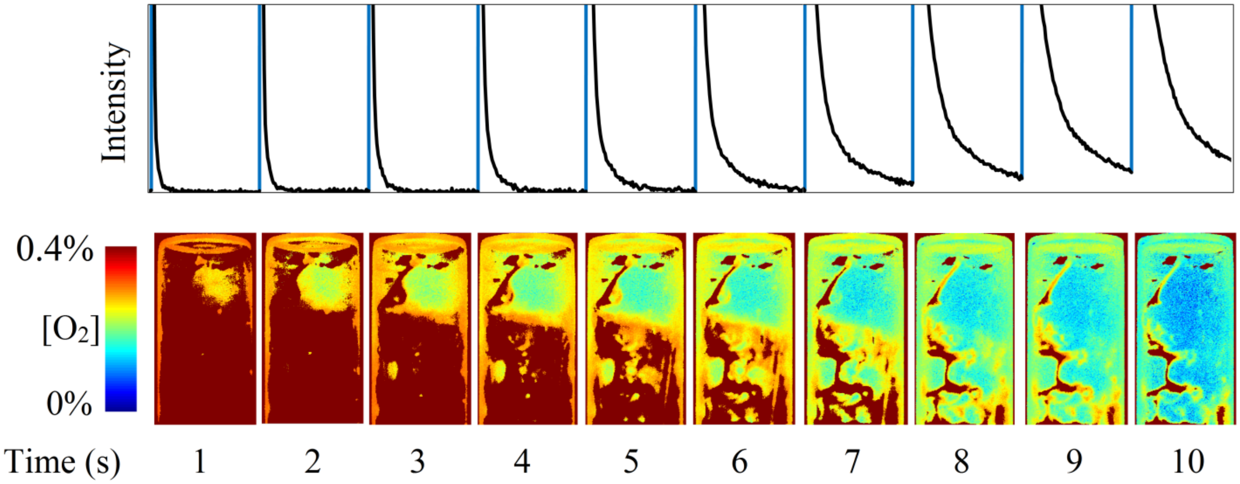

Figure S6. RLD imaging of nitrogen stream purging a vial containing a film of sample **2** over time. Intensity plots of an ROI (perceived excitation in blue, sample decay in black) are shown above corresponding colormaps. Here we demonstrate increased temporal resolution with pulses only 1 s apart.