Electronic Supplementary Information

Fast-response oxygen sensitive transparent coating for inner pressure ratiometric optical mapping

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Supplementary Experimental Detials

Numerical simulation

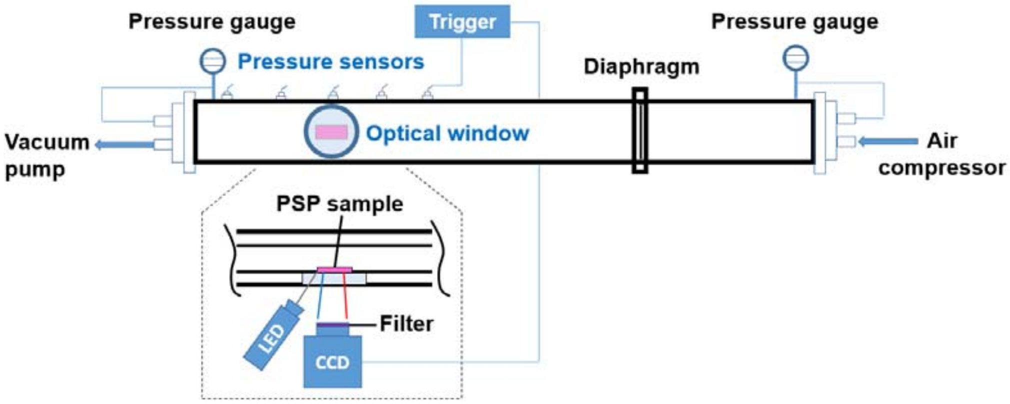
Governing equations including compressible Navier-Stokes equations assuming laminar flow were employed,

$$\frac{\partial U}{\partial t}+\frac{\partial F}{\partial x}+\frac{\partial G}{\partial y}=\frac{\partial F_v}{\partial x}+\frac{\partial G_v}{\partial y}$$

$$U=\begin{bmatrix}\rho\\ \rho u\\ \rho v\\ E\end{bmatrix}\quad F=\begin{bmatrix}\rho u\\ \rho u^2+p\\ \rho uv\\ u(E+p)\end{bmatrix}\quad G=\begin{bmatrix}\rho v\\ \rho uv\\ \rho v^2+p\\ v(E+p)\end{bmatrix}\quad F_v=\begin{bmatrix}0\\ \tau_{xx}\\ \tau_{xy}\\ u\tau_{xx}+v\tau_{xy}+q_x\end{bmatrix}\quad G_v=\begin{bmatrix}0\\ \tau_{xy}\\ \tau_{yy}\\ u\tau_{xy}+v\tau_{yy}+q_y\end{bmatrix}$$

where U is the conservative variable vector, F and G are the inviscid flux vectors, F_v and G_v are the viscous flux vectors respectively, and ρ, u, and E are density, velocity, and total energy per unit volume. The governing equations were solved using a finite difference approach. Convective terms were approximated using the Roe-FDS scheme and the central difference method was applied to the viscous terms. No-slip and isothermal boundary conditions were specified as the boundary conditions at the wall. And temperature was set to 300 K.

Supplementary Scheme



Scheme S1. The setup of shock tube for the testing the unsteady aerodynamic performance of the transparent PSP coating. The shock tube has a square section of 84 × 84 mm, a long driver section of 0.5 m and a long low pressure section of 2.2 m. A quartz window with a diameter of 60 mm is placed on the vertical wall of the tube at 0.8 m from the low pressure section, on which a sample plate (50×25×1.2 mm) was pasted with the coating surface towards the inner section, leaving an attack angel of 0°. Outside the quartz window, a LED array (λ_{ex} = 365 nm) and a high-speed CCD camera (FASTCAM Mini AX 200, Japan) equipped with a 410 nm filter were placed. The camera was connected to a trigger (DG535, USA) and set at a recording speed of 10000 Hz (0.1 ms per picture) with a resolution of 1024 × 672 pixels. The experiments were started at 25°C, when the low pressure section was filled with air at an initial pressure of 20 kPa.

Supplementary Figures

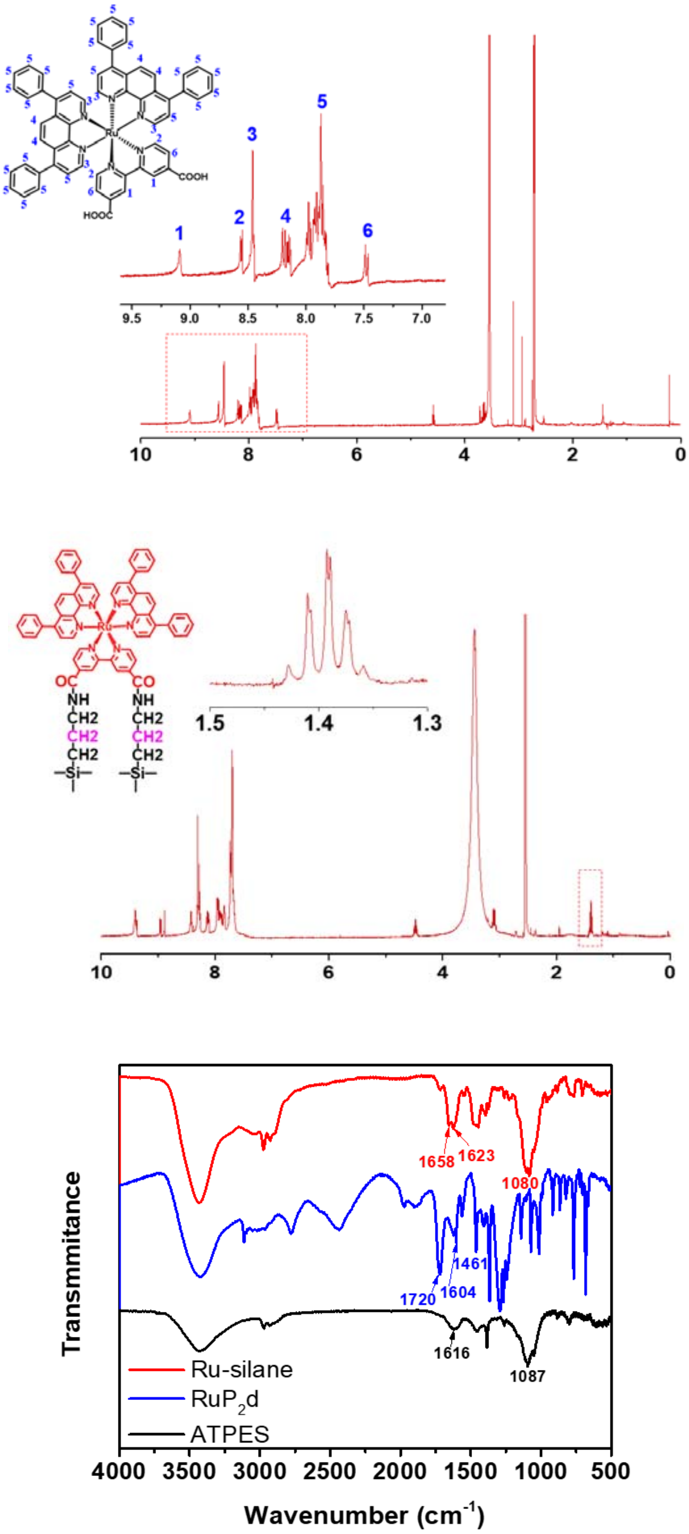


Figure S1. [1]H NMR and FTIR spectra of RuP2d and Ru-silane.

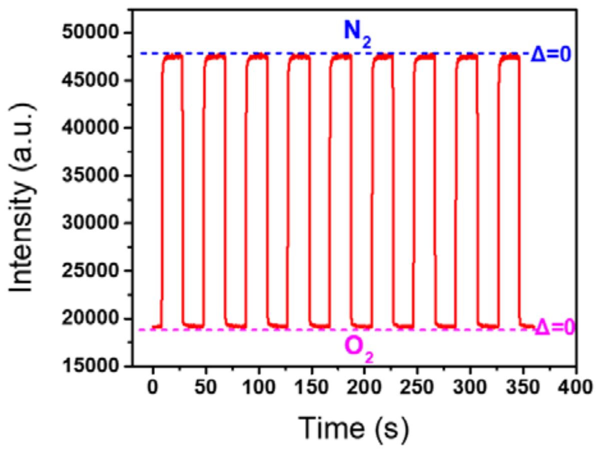


Figure S2. Photostability and sensitivity of the transparent bi-layer PSP coating upon the alternation of nitrogen and oxygen atmosphere in 6 min.

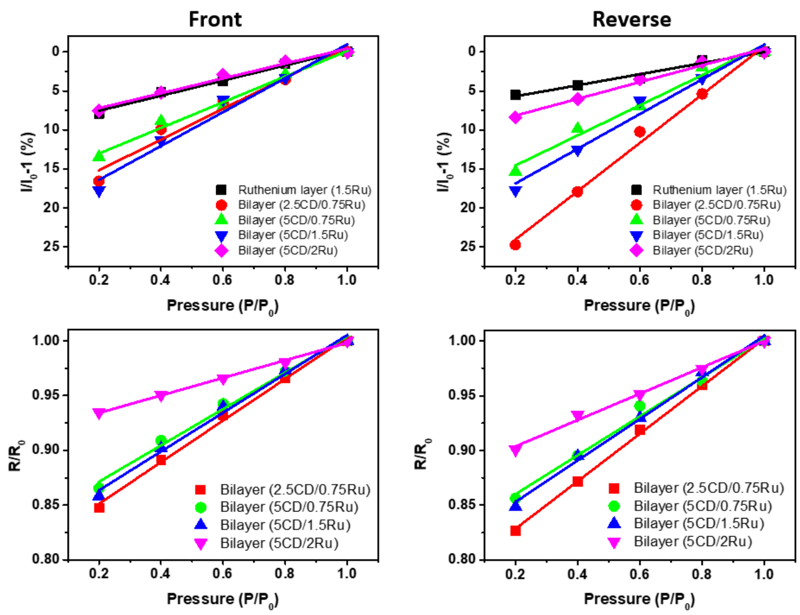


Figure S3. Influence of chemical composition in the PSP coatings on their sensitivity to the surface pressure. xCDyRu presents that the composition of SiCDs and Ru-silane was x mg/mL and y mg/mL in the reference paint and the sensitive paint for making the coating respectively.

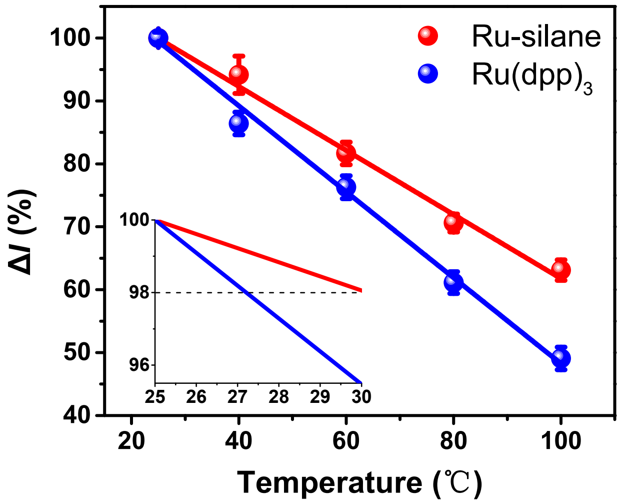


Figure S4. Temperature dependence of Ru-silane and Ru(dpp)$_3$ emission after being chemically grafted or physically entrapped onto the surface of bi-layer PSP coating.